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PROA LADRONIA.

THIS boat was built on Cayuga Lake, N. Y., 1877, for T. M. Prentiss, Boston, Mass. (Named for the Ladrone Islands, where the "Flying Proa" originated.)

CONSTRUCTION.—HULLS.

Two half sections of a boat—closed.

Inner Sides.—Smooth and straight from end to end.

Upper Sides.—Flat and at right angles with inner sides.

Outer Sides.—Modeled with as much attention given to lines as for a single boat, gaining thereby greater bulk and buoyancy than is possible in straight-sided round tubes or simply boat-shaped pontoons; immense reserve of floating power being essential in a double boat to prevent the leeward hull from being submerged in rough weather.

Ribs of hulls are of oak, covered with ¾ inch pine. Length of hulls over all, 17 feet; width, upper sides, amidships, 18 inches; depth, inner or flat sides, amidships, 30 inches; depth at bow, 29 inches; depth at stern, 24 inches. The hulls are placed 5 feet apart, and connected together by six transverse beams, each 3 inches square, firmly bolted and riveted, alike to the inner and outer sides of hulls.

Each hull is provided with a 2½ inch brass deck-screw for the purpose of pumping out. As yet there has been no occasion to use a pump.

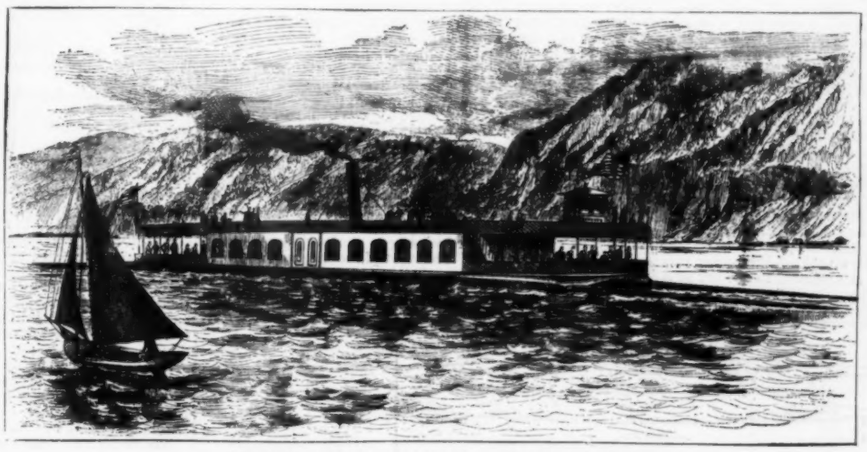
DECK.

The deck or platform—laid in alternate strips of butternut and pine, ¾ inch thick and matched—is semicircular in shape at the bow and stern. Extreme length of deck, 15 feet; extreme width of deck, 8½ feet. The under surface of deck is sheathed and painted, to prevent any resistance of the cross-beams to the passage of water between the two hulls.

Railing of oak—2 feet high—round the deck, having a base board 4 inches wide, and top board 2 inches wide. Intervening space—18 inches—of rope netting, painted red and white.

BULWARKS.

Painted oilcloth, wound round two spring window-shade rollers placed perpendicularly inside a close-fitting black walnut case, serves for bulwarks to protect against spray when beating to windward in rough weather.



NEW CATAMARAN STEAMER.

The Mast—21 feet; is stepped 5 feet from bows, midway between the hulls. It is square at the foot, where it is made to slip easily into and out of a black walnut box, 18 inches deep. The latter is mortised to one of the deck beams (second one from the bows), and supported by four iron braces riveted to three of the beams, placed nearer together for that purpose when laid than the three aft beams.

RIGGING.

Length of boom, 21 feet; length of yard, 24 feet. Four blocks only are used, three of them single and one double.

The Sail.—Pattern, modified lateen, dimensions, 28½ square yards. Is hoisted by a single halyard, by which alone it is held to the mast above; and below by a stout wooden hoop attached to the boom where it crosses the mast—say 5 feet from the deck—thereby insuring ample head-room, and allowing the sail to veer with the wind as freely as a weather-cock, which is particularly advantageous in heavy flaws, as it obviates the necessity of luffing to avoid unusual strain upon mast or rigging.

PERFORMANCE.

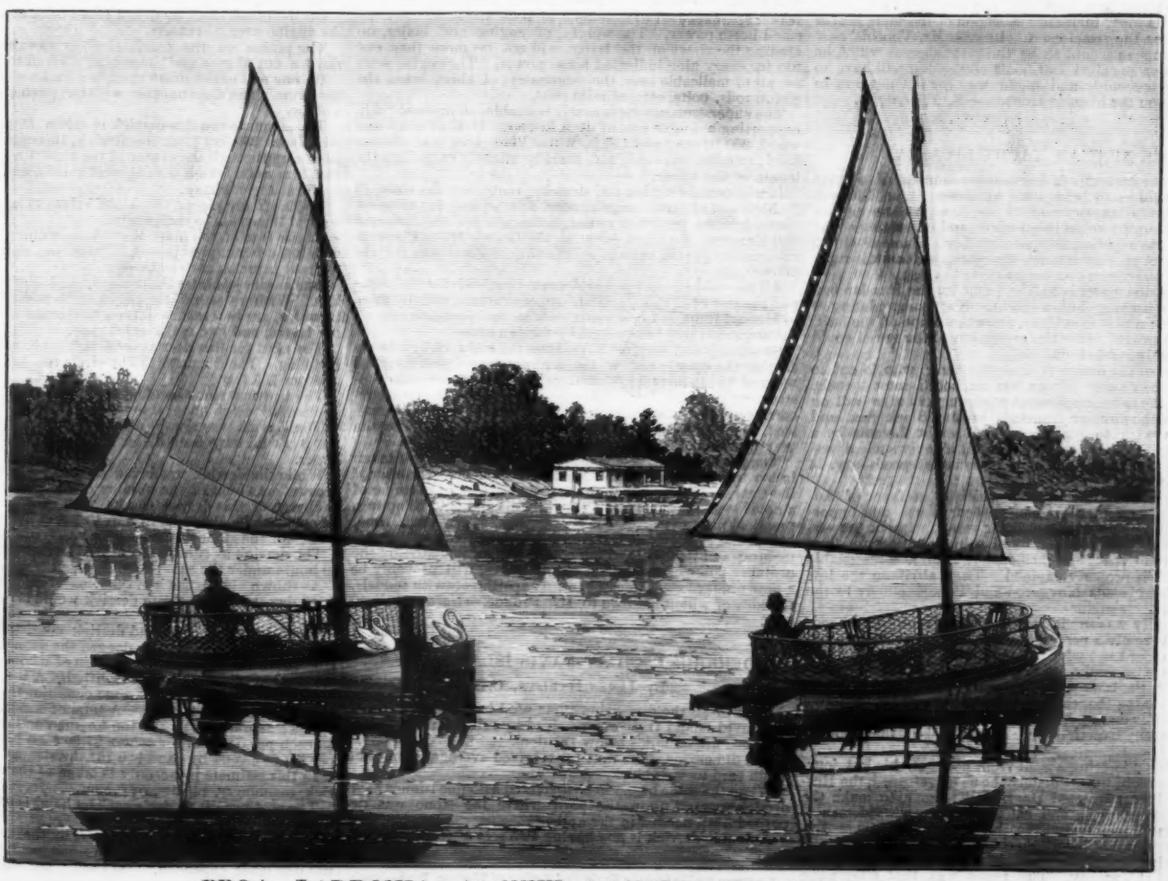
Capsizing seems to be an impossibility with this craft. So great is her stability that the mast and entire rigging have been blown overboard without so much as stirring a camp-chair on deck.

Gibing may be simply denominated one of her most innocent performances.

Being wonderfully steady under canvas, by reason of her double construction, she is wholly independent of ballast.

The flat side of the windward boat always acts as a centerboard; and both hulls being closed against the ingress of water, she never requires bailing. Any water she may ship discharges itself at once without doing any harm. Her weight is about 1,500 pounds, and she draws 6 inches of water.

She sails and steers well on all points, and will lay closer to the wind than most ordinary boats, owing probably to the two keels, which give a double hold on the water. On this is largely dependent the ease with which the Ladronia



PROA LADRONIA—A NEW DOUBLE PLEASURE BOAT.

may be put about. With skillful management of the helm, while close to the wind, she rarely misses stays. A dexterous movement of the tiller at certain points of tacking seldom fails to put her about speedily.

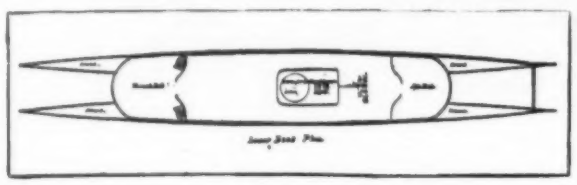
This boat was not built for sea service, but merely to be *safer* and steadier in protected waters than the common open boat. Neither is she suitably rigged for speed, and yet she has repeatedly outsailed the fastest boat hereabouts; one 5 or 6 feet longer than the Proa, carrying double her spread of canvas, and that has always taken the first prize in regattas on this lake.

My object in adopting this style of craft is to render boating here a safe recreation for the ladies of Wells College, who have appreciated, during the past season, the comfort of her roomy deck and freedom from pitching and careening, and my purpose in giving you the result of this experiment is solely that you may call to the attention of your nautical readers a double hulled boat differing in many particulars from those heretofore introduced into our waters, and whose merits it will always give me pleasure to discuss with *any* of your readers, giving them such further details of construction and performance as may be required.

Aurora, N. Y. T. M. PRENTISS.

A CATAMARAN STEAMER.

WE illustrate on the first page a novel steamboat now building at Nyack, under the superintendence of Mr. William Voorhis, of that place, formerly Commodore of the New York Yacht Club. The new boat is to be in the form of a catamaran, and it is expected she will exceed in speed any ever constructed. She will have a double hull, 200 ft. in length, while, as a whole, she will have twenty-five feet beam. Her engines will be of a pattern suited to the character of the craft, and turn a single wheel—to be placed between the parts of the double hull—of eight feet in diameter, at the rate of 325 revolutions per minute. It should be mentioned that her hull, or rather hulls, are to be of iron, each five feet six inches in diameter and cigar shaped. Of course, it will be understood that she will have no cabins below the water, as in the ordinary steamboat. On account of a peculiar boiler Mr. Voorhis expects to be able, with perfect safety, to carry 125 pounds of steam to the square inch, whereas the common boats rarely exceed from thirty to thirty-five pounds. Great speed is expected to result from the following considerations: From the length and narrowness of the engine cylinders, giving great speed to the machinery, and from the shallow draught of water, the draught amidships being less than three feet and gradually diminishing to nothing fore and aft. In proportion to her displacement no other boat has one-third the power this novel steamer will possess. It is intended to use her as a passenger boat, and her carrying capacity will be seventy-three tons, or about 500 passengers. She will have four bulkheads, comprising five air-tight compartments, which will be placed nine feet apart, and the deck over her center will be 125 feet long, including a saloon of the same length and as wide as the vessel itself. In case Mr. Voorhis' new nautical venture turns out to be the great success which he anticipates, the so-called fast boats of the day will have to retire on their records and make way for the new era in steamboating on the historic Hudson.—*N. Y. Graphic.*



A CATAMARAN STEAMER.

THE RUSSIAN YACHT LIVADIA.

IN one of our contemporaries mention is made of a great Russian war ship now being built by Messrs. John Elder & Co., at Govan, Glasgow, and, as we have had an opportunity of seeing the vessel in question, and of hearing something about the experiments made on Loch Lomond with a working model of this strange structure, we think it right to enlighten our readers on the subject.

The fact is, the vessel is to be a yacht for the Russian emperor, and is nothing but a yacht. No armor plating is contemplated; and it is evident, from the shape of the hull, that no such provision for the protection of the vessel could be subsequently carried out.

The origin of the design is, that the Czar, who is apt to suffer from the motion of the sea on board most vessels, did not feel the usual unpleasant consequences of a sail on board one of the circular ironclads in the Black Sea, and expressed a wish to replace his lost yacht Livadia by a new Livadia, of nearly circular form, if only such a vessel could be made to steam at a reasonable speed—say, 13 knots per hour.

The party in the Russian navy which is in favor of Admiral Popoff's circular vessels, wished to use this opportunity for building a nearly circular vessel, without the vertical sides required for an armored ship, and thus to show that very broad vessels might be made to go at a reasonable rate of speed, if properly engined. They attribute the low speed of the cyclads Novgorod and Popoff chiefly to the weakness of their engines.

The difficulty was to make sure of the speed beforehand, and this was really a perplexing question, as every one will be able to understand who is familiar with naval architecture, and, consequently, knows how little has been ascertained about the laws which govern the resistance of floating bodies having shapes very different from the usual forms of ships. Only one way is open in such a case, namely, that of carefully experimenting with models of the proposed vessel.

Mr. W. Froude being absent from home on his last journey, from which, unfortunately, he never returned, the Russian authorities requested Dr. B. J. Tideman to make the necessary experiments and calculations. Dr. Tideman is the chief naval architect of the Dutch navy, and has at Amsterdam dockyard at his disposal an experimental basin and model-making machine, similar in most respects to those of Mr. Froude at Torquay. The result was, that after some slight alteration had been made in the lines of the proposed ship, the scheme was pronounced to be feasible, or, in other words, that a speed of, at least, 14 knots could be obtained.

In order, however, not to spend a large sum of money in the construction of a vessel against the opinion of some of the Russian naval authorities, without taking every possible precaution against failure, the Russian government insisted on certain conditions on which their order for building was to be accepted.

Messrs. John Elder & Co., after having examined carefully the feasibility of the desired structure, and the fulfillment of its conditions as to speed, undertook to build the vessel.

A working model was now made, with a view to ascertain what could be done to promote the success of the yacht, as far as regarded the choice of pitch of the propellers, and also to find out how much the working of the proposed or any other screws would add to the resistance of the hull; so that, if necessary, the indicated power of the engines for the yacht might be brought to a maximum by increasing the number of revolutions and, perhaps, the boiler power.

These experiments have now been commenced, and, as far as can be judged by an outsider, from the speed of the working model which represents the vessel on a scale of 0·1, it seems that no failure is to be feared; for we estimate the speed with which the little craft passed over the Clyde at something over 5 knots an hour, which, for a vessel of ten times the linear dimensions and proportionate power, would be equal to 5 √10, or nearly 15·8 knots.

We shall now briefly describe the yacht, as it is being constructed, remarking, in the meanwhile, that it will be perhaps the safest vessel afloat, because a collision—even with the bow of a ram—could scarcely endanger its floating power, owing to the large number of bulkheads, concentric as well as radial; and even the possible contact with a rocky coast would not destroy its double bottom, subdivided as it is into so many water-tight compartments.

The yacht is 230 ft. long, and has an extreme breadth of 153 ft. The draught of water is 6 ft. 3 in.; but the screws, which are three in number, will want 15 ft. 6 in. of water to enable them to revolve. The displacement of the vessel, when carrying coal sufficient for five days, will be 3,920 tons.

The general form of the yacht has been compared to that of an enormous steel turbot with a palace on its back. The turbot part is to be about half immersed. The lines of the upper structure are not quite square, but somewhat in the shape of a ship. The depth of the fish-like raft in the center is 18 ft., and the water line is only 6 ft. above its lowest point, excepting the three wooden keels which project from the bottom. At the stern, a depression is effected, for the purpose of giving the screws water to work in, thus making a draught of 16 ft. in all. This part of the ship may be lifted when it is necessary to cross shallows.

The motive power will be supplied by three screws, the outer ones of which are 36 ft. apart. The screws are of manganese bronze, so as to combine strength with lightness The screws are worked by three sets of compound engines, which are expected to develop a total of about 12,000 indicated horse power. The weight of engine and boiler, including the water of the latter, will not be more than one ton for every nine indicated horse power. The engine seats are all of malleable iron, the condensers of sheet brass, the piston rods, bolts, etc., of mild steel.

The superstructure more nearly resembles an ordinary ship supporting a double row of deck houses. It is of steel and wood, 260 ft. long and 110 ft. wide. The bow is of clipper form, trending forward, and thereby slightly extending the length of the whole.

It will contain dining and drawing rooms for the Czar, 12 ft. high and of great magnificence, apartments for aides-de-camp, saloons, reception rooms, bedrooms for the Emperor and Empress, the High Admiral, the Grand Duke Constantine, cabins for the captain of the ship, a wardroom for the officers, etc.

All the cabinet and joiners' work required for finishing and ornamenting the elaborate superstructure will be done in Messrs. Elder & Co.'s yard; but in the decorative part, the workmen will be directed by foreign artists.

Steadiness and comfort have been the main object in designing the vessel; and if the maximum of steadiness be secured in this yacht, it will often show the way to construct on the same principle the most stable floating gun-carriage. If, at the same time, the intended speed be realized, together with great ease in steering, it would be the very best model for a channel steamer.

The yacht is an experiment, and the great interest taken in her by the Grand Duke Constantine, the eldest brother of the Czar, is largely due to the fact that she is an example of a novel system of construction which he wants to bring into practical use in the Russian navy. But, at the same time, it is of the greatest interest to all concerned in naval architecture; and its speed, which could not be calculated by the ordinary rules of theoretical shipbuilding, will probably be a new proof of the value of careful experiments with models, the idea of which we owe to Mr. Froude.—*Universal Engineer.*

DERRICK USED AT DAVIS ISLAND DAM.*

By JAMES HARLOW, C.E.

NEARLY all the dimension stone used in the lock walls of the David Island Dam was received by rail from the Baden quarries, fifteen miles below the dam.

The dimension stone thus far received averages about one cubic yard to each block.

When the stone began to be delivered a double runner hand derrick was put up in the yard where the stone was deposited until needed in the walls.

A double derrick is one having two sets of falls, and machinery for working the same. At the foot of the mast on each side, and at right angles to the boom, the framework is so arranged that a crank shaft and drum for working the fall lines can be placed upon it.

The crank shaft has on each end a crank for man power and a pinion; on the shaft is also an arrangement for holding the shaft in gear with the drum. Just back of the crank shaft and near the mast is the drum shaft, on each end of which is a spur wheel which gears into the pinion on the crank shaft. The crank shaft moves so that either or both of the pinions may be out of gear with the drum shaft.

The pinions on the crank shaft are so arranged that only one can be in gear with the drum shaft at the same time.

The spur wheel and its pinion on each end of the shafts are of different diameters, so that the speed can be increased when the weight to be lifted is decreased and *vice versa.*

The line running from the drum to the head of the mast, then to the end of the boom, and then through double and treble blocks, is called the "fall."

The upper or double block on this line is fastened to the end of the boom.

The lower or treble block is movable, and rises or falls with the load.

Another line running from the drum to the head of the mast, thence through double and treble blocks, is called the "runner."

The upper or double block is made fast at the head of the mast, or in order to save rope at the end of a single line, usually of wire, between the head of the mast and a point within the line of the boom.

This single line of wire must be of equal strength to the five it displaces.

The treble block on this line is fastened to the treble block of the fall and moves with it.

The boom is held in position in the usual manner by the boom fall, consisting of a double block fastened at the head of the mast and a double block made fast at the end of the boom, the end of the line being made fast over a cleat at the foot of the mast.

With a double derrick the boom is placed in the best position and allowed to remain, and the stone lifted within the limit of the boom by the "fall" and "runner" lines.

Supposing a stone to be lifted by the derrick, it can be moved out from the mast and on the same level by *lowering* the runner and *hoisting* the fall.

It may also be moved out from the mast and at the same time raised by *holding* the runner and *hoisting* the fall. By reversing this operation the stone is moved toward the mast.

Hoisting or lowering uniformly with both lines will raise or lower the stone vertically.

A derrick of the above description was first placed in the yard, but it could not be made to do the work required, although worked from 5 A. M. to 8 P. M., with a loss of about one-half hour for breakfast and one-half hour for dinner, making the actual working time about fourteen hours per day.

As the delivery of stone was hindered by the inability to handle the stone in the yard, Lieut. Mahan, in charge of the work, decided to apply some power other than hand power to the derrick. Various plans were discussed, and the one herein described was adopted.

The derrick was not changed, except to take off the hand power and build a framing of oak, which was bolted to the mast at right angles to the boom. On each of two opposite diagonal corners of this frame is bolted a small single engine. The cylinder of this engine is four inches in diameter and eight inches stroke. The engine is what is known as the "nigger reverse." The connecting rod of the engine is connected to the crank shaft, on which is a pinion with 22 teeth; this pinion gears into a spur wheel with 68 teeth on an idler shaft, which in turn, by a pinion of 22 teeth, is geared to the drum shaft by a spur wheel having 80 teeth.

On the crank shaft there is a small balance wheel to assist the engine over its centers.

The pinion on the crank shaft is movable so as to be thrown out of gear and the engine allowed to run.

On one end of the drum shaft is a brake wheel to control the drum when disconnected with the engine or in lowering a stone.

The steam to run this derrick is taken from boilers situated about 250 feet from the derrick, through a pipe which passes up through the center of the mast to just below the platform upon which the engineer stands, and terminates in a T near the engineer.

On this T are placed two globe valves to act as throttles to control the steam to each engine.

At the foot of the mast there is a stuffing box through which the steam pipe passes, so that the derrick can turn without injuring the steam pipe.

One engine operates the runner, and the other the fall line. Within reach of the engineer, in addition to the two throttles, are two reverse levers, two brake levers, two shifting levers, and two cylinder oil cups.

The mast for this derrick is 60 feet high, and the boom 70 feet long. The diameter of the circle reached by the derrick is about 125 feet.

The heaviest stone handled contained about 93 cubic feet, and would weigh about 6 tons.

The derrick was always able to handle any stone required, but it would have been better had the cylinders been a little larger.

While the derrick was being worked by hand no accurate account was kept of the number of lifts made, but the man in charge of this derrick thinks, with everything favorable, he could make about 60 lifts in 10 hours, including the lifts made for the stone cutters within reach of derrick.

The derrick as run by steam will make about 150 lifts in 10 hours under the same conditions.

As shown above, the hand derrick would make a lift in 0·167 day, while the steam derrick would make a lift in 0·067 day.

The force to run the hand derrick consisted on the average of 1 foreman (who also dogged the stone), 1 tagman, 4 laborers at the derrick, one or more of whom acted as assistant tagmen after the stone was lifted. A total of 6 men.

The steam derrick under same conditions required 1 foreman, 1 engineer, 2 tagmen. A total of 4 men.

If we assume the pay of the foreman and engineer to be $3 each per day and the others $1.50 each per day, the cost per lift *in dollars* by hand is 0·167, by steam 0·047.

In this estimate no account is taken of the cost of the derrick, machinery, repairs, or steam.

The cost per lift *in day's work* by hand is 0·100; by steam 0·026.

The amount of useful work done by the use of steam as compared to hand power is: In stone handled, 2·50 times; per day labor expended, 3·85 times; per dollar expended, 3·56 times.

*[A paper read before the Engineers' Society of Western Pennsylvania, January 20, 1880.

A FEAT IN TRIANGULATION.

A NOTEWORTHY advance in geodesy has recently been accomplished by the junction of the network of measurements covering a large portion of the surface of Europe, with the African continent. The entire triangulation of Algeria was completed by French engineers some time since, and extended to the edge of the Sahara, in lat. 37°. Mr. Perrier, who had directed in a great measure the triangulation of Algeria, has for the past eleven years been seeking the means of joining the net work in that country with the perfect trigonometric system covering the surface of Spain, France, and England. The importance of such a junction is easily appreciated when we consider what notable changes in the accurate conception of the shape of the earth and of the length of meridians has been effected by measurements on a much smaller scale.

For such an undertaking the most careful and painstaking preparations were requisite. As the result of his reconnoissances between 1868 and 1872, M. Perrier found that from all the trigonometric points of the first order between Oran and the frontiers of Morocco, the loftier crests of the Sierra Nevada on the Spanish coast opposite were visible in exceptionally clear weather. Arrangements were subsequently made with the Spanish Geographical Institute for the mutual and contemporaneous execution of the proposed plan.

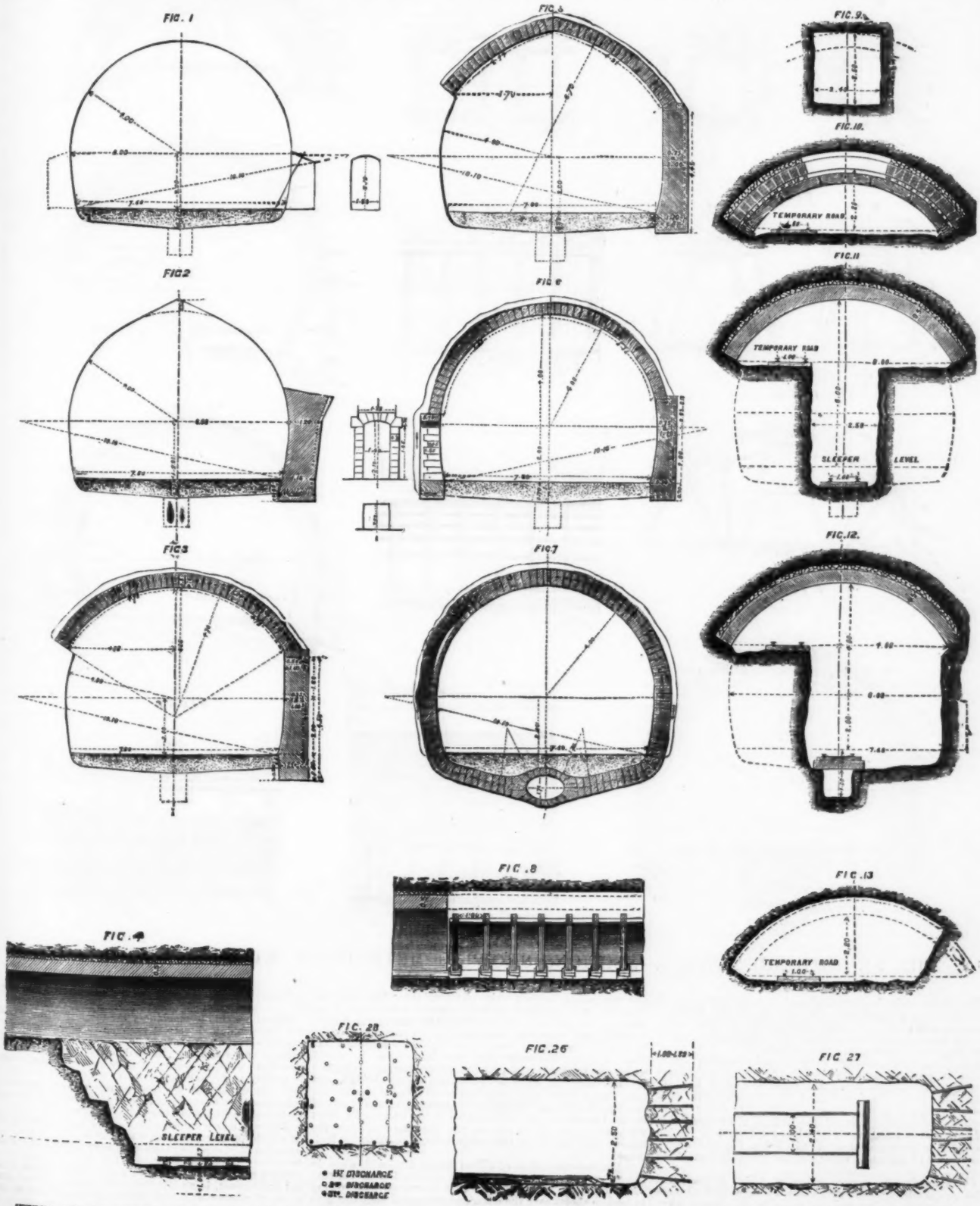
A corps of Spanish officers, under the direction of the well-known General Ibanez, was detailed for this purpose, while the French Minister of War placed a division of officers from the *Etat-Major* under the command of M. Perrier. The leaders chose for stations in Algeria the summits of Mount Filhaoursen and Mount M'Sabiha, west of Oran, and in Spain the summits of Mount Tetica and Mount Mulhacen, the latter of which is the most elevated point in the kingdom. The directions and distances between these four points were computed as carefully as possible, and preparations were then made for the final and determinative observations. At the Algerian stations the nature of the country and its inhabitants necessitated the use of a numerous force of soldiery as well as of means of transport.

In order to insure the accuracy of the observations, which required the passage of signals over a distance of 270 kilometers, it was decided to make use of solar reflectors and powerful lenses. The efficacy of such apparatus for even greater distances had already been tested by M. Perrier; still for the measurements in question they appear to have utterly failed to answer the expectations based upon them, not a single solar signal being visible from any station. Fortunately, the success of the observations did not rest entirely upon this one system of signals. Preparations had likewise been made for the employment of the electric light, and on the summit of each mountain, one of Gramme's electro-magnetic machines worked by engines of six horse power had been placed in position.

On August 20 last, all the stations were occupied, and the electric lights were displayed throughout each night. Then the patience of the observers was submitted to a lengthy proof. The mists rising from the Mediterranean totally prevented the exchange of signals until, after a delay of twenty days, one after another the electric lights became visible even to the naked eye. Perrier compared the intensity of the light on Tetica, nearly 270 kilometers distant, to that of Alpha in Ursa Major, which rose near by. The observations were continued from September 9 to October 18, when this task, for which such extensive preparations had been made, was completed in the most satisfactory manner. With its completion we come into possession of trigonometric measurements of the most exact nature, extending from lat. 61° in the Shetland Islands, to lat. 34° on the southern frontier of Algeria.—*T. H. N. in Nature.*

THE ST. GOTHARD TUNNEL.

THE nature of the strata to be pierced varies very much, and different methods of construction, all based on what is known as the Belgian system, are adopted as seems best suited to the nature of the ground. Fig. 1 is a section of the tunnel in very solid rock, without fissures and without



THE ST. GOTHARD TUNNEL.—SECTIONS SHOWING METHODS OF WORKING.—GOSCHENEN END.

masonry lining. Fig. 2 is another section in much the same kind of rock, but it will be seen that on one side a masonry wall has been introduced, to make up for a deficiency in the rock. Fig. 3 is a section in solid fissured rock. The roof is of masonry, sometimes with and sometimes without side walls, as shown. Fig. 4 above is a vertical section in the direction of the axis of the tunnel in the stage shown at Fig. 11. Fig. 5 shows a section in many respects identical with Fig. 3; the rock is solid, but fissured. Fig. 6 shows the section in friable or treacherous rock; the tunnel being lined throughout. Fig. 7 is the section adopted in soft strata, liable to yield to lateral pressure. A slight modification of this section was used where the semi-fluid pressure of the plastic stratum had to be withstood. Fig. 8 shows a portion of tunnel lined with masonry, and Fig. 9 is the advance heading, the curved dotted lines showing its position with relation to the finished tunnel. Figs. 10, 11, 12, and 13 show the successive stages of the system on which the excavation proceeds, and explain themselves.

MUSIC IN THE SAWMILLS.

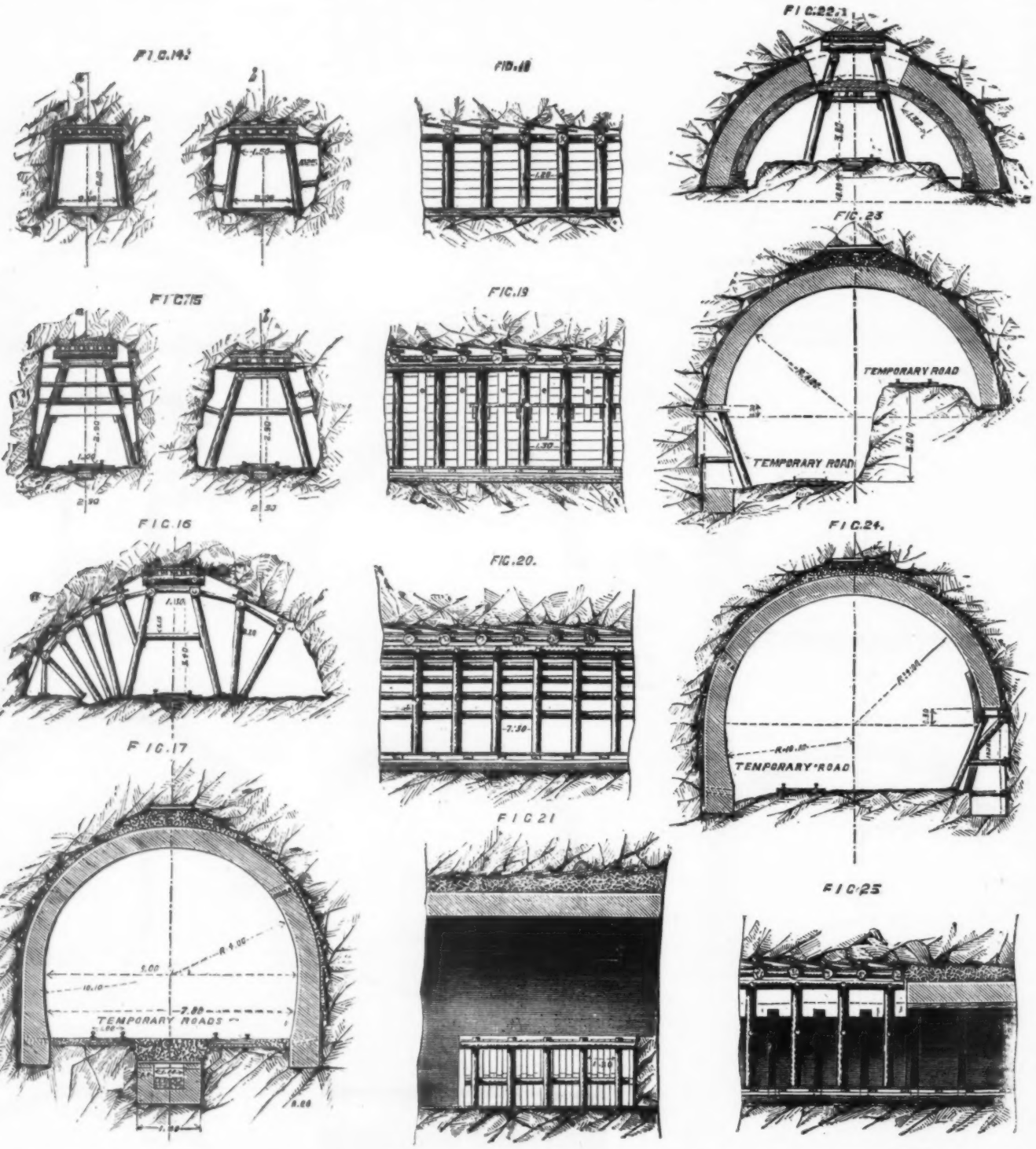
In the erection of a mill building, the question of vibration and oscillation is too much neglected. Many a man has commented upon the jar of his mill frame, and all must have noticed that with an excessive vibration of the entire mill floor when the saw was running light, the whole structure became comparatively quiet and at rest the moment the saw struck into a cut. This motion is often due to a weakness of the frame, but is not seldom the result of vibration caused by impulses synchronous with the key note of the building. Not only every musical instrument has its key note, but as well every bridge which crosses our rivers, and every factory, mill, and dwelling. A familiar illustration may be found in the fact that upon all the great bridges of the world, the marching in step of a body of men or the playing of music by a band is strictly forbidden. This is from the fact that it is impossible to tell at what moment the key upon which the bridge is tensioned may be struck, and responding, begin a series of vibrations, which may increase in their intensity until the structure shall fall from the development and accumulation of the gathering forces. It is said that upon one occasion the strength of a bridge being under discussion, a wager was laid by a musician that with no other instrumentality than his violin, he would shake the bridge to the point of its destruction. Taking his instrument in hand he proceeded to the bridge, and after many hours of unsuccessful endeavor, at last struck the proper note, and the bridge responding to the chord of music, became so violently agitated in the course of a short time, as to lead its owners to pay the wager and stop the music. A writer upon this subject cites the following incident:

"The superintendent of a New Hampshire mill, when in the factory on Sunday, was greatly surprised at the shaking of the building. He observed that the water was flowing in broken sheets over the dam, and presumed that the pulsations of air were synchronous with the key note of the mill; continuing his observations, he learned that with a greater or a smaller flow of water over the dam, the mill was at rest; and also with the scuttle in the roof open, so that the puffs of outside air were in free communication with the interior of the mill, the vibration was much greater than when the scuttle was closed.

At Centerdale, R. I., the water flowing over the dam caused at times a great vibration in the mill. This has been stopped by fastening vertical pieces of plank, at intervals of ten feet, against the front of the dam, and projecting upward so as to break the long sheet of water into numerous short falls, whose key note was different from that of the whole sheet of water which they displaced.

At the Essex Woolen Company, mill No. 8 is sometimes thrown into vibration by the water flowing over the dam, and when this happens the watchman on duty alters the note of the dam by opening the waste gate, and the mill soon comes to rest. Mill No. 5 of the same company, but at a privilege lower down the stream, is often thrown into vibration by the falling water at that point, and the story is told that a watchman once fled from that mill, thinking that it was about to fall."

Vibrations due to machinery are often stopped by changing the speed, and were it possible to place the posts and supports irregularly, instead of in the uniform manner, customary and necessary, the vibrations would become very much less likely to occur. The principle of wave currents is getting to be well understood, and their intensification and adaptation through the medium of the telephone and microphone in connection with a tight wire and the application of electricity are becoming familiar principles. The audiphone, a thin rubber disk looking like a fan, the point of which touches the teeth while the handle is held by the experimenter, enabling those who have never heard a sound to receive impressions through the teeth, even to the discerning of the various notes of a tune played upon a musical instrument, is an illustration in point. A well braced piece of timber will send forth a musical note on being struck; if it be slack braced, it gives in return but a dull, unmusical sound. A woodsman will clear the bark from a



THE ST. GOTHARD TUNNEL.—SECTIONS SHOWING METHODS OF WORKING.—AIROLO END.

Fig. 14 shows the heading timbered, *a* in moderately good ground, *b*, in fissured rock. Fig. 15 shows the heading enlarged, *a* in moderately good ground, *b* in fissured rock. Fig. 16 shows the timbering of the widened tunnel, *a* and *b* denoting sound and fissured rock as before.

Fig. 17 shows the masonry of the tunnel complete. Fig. 18 is a longitudinal section of *a*, Fig. 14. Fig. 19 is the same as *a*, Fig. 15. Fig. 20 is a longitudinal section of Fig. 16. Fig. 25 is a longitudinal section of Fig. 22, while Fig. 21 is a similar section of Fig. 23 and of Fig. 24, showing the method of supporting parts of the arch of the tunnel while the side wall is built in. Fig. 26 gives a vertical section showing the arrangement of the shot holes. Fig. 27 is a horizontal view of the same, while Fig. 28 gives the face of the heading.

The dynamite, the greater power of which as compared with gunpowder for hard rocks was an important element in the estimates of time and cost made by M. Favre when tendering, is generally used in iron cartridge cases.—*The Engineer.*

small spot on top of a suspected prostrate tree or log, judging from the musical ring which responds to a blow from the back of his ax upon this spot, that no decay or breakage of the fiber has taken place in the timber. If decay be present or punky streaks exist, the blow is responded to but by a dull thud. The clear ringing of the saws in a mill, particularly at night, is due to the vibrating responsiveness of the mill frame, as well as to the condition of the atmosphere.

Oscillation is a different matter, and is caused by external forces operating upon a weakness, comparatively speaking, of the subject operated upon. A mill may oscillate and sway under the force of the wind, but a frame largely subject to oscillatory influences will give but little response to the forces which will cause vibration. A wire hung loosely from the ceiling will, on being struck, oscillate or sway from one side to the other, but if both ends be confined, and the wire be drawn tight, a blow will cause vibration which will produce musical results, either upon a higher or lower key.

A mill frame, loosely constructed, will respond to the movement of the machinery with scarcely a vibration, but such a mill will shake from center to circumference, perhaps, upon rolling a log across the skids, or turning it down upon the carriage, while the sounds emanating from the saws will be muffled and dead. Under the same experiment a well braced, tightly keyed building will vibrate in every fiber of its frame, and the singing of the saw and the hum of its machinery will inspire all within the range of its sound with the energy which the warmth and color of life never fail to impart.

Many of the phenomena and mysteries connected with so called spirit manifestations are no doubt explainable upon the theories of vibration, and without doubt the principle of acoustics as applied to public halls and to dwellings must, to be profitable, be found in a study of this subject. Some buildings are noted for conveying sound, words spoken in one room being heard with comparative distinctness in another. This is often an annoyance which may be prevented by laying paper on the joists before the floors are laid. A layer of ordinary building paper is far more effective to this end than the usual deadening by mortar, which partakes to a goodly extent of the rigid nature of the timber, and the tighter it is packed the more telephonic it becomes in its nature. To illustrate this point, take a string, one end of which is secured to a post, the other held in the hand loosely. Striking upon it will produce little or no vibration through its length, for the reason that the vibratory currents will be broken in their contact with each other. Stretch it tight and the same weight of blow will produce vibratory waves chasing each other with a metallic or musical sound throughout its entire length. The drum is an illustration in point so familiar as to need no comment. To muffle its sound a handkerchief has but to be drawn through its snares and the partially broken vibrations yield but the dismal and unmusical sounds supposed to be the most appropriate for a dead march.

If we apply the principle of vibratory acoustics to a sawmill we can produce a resonant and invigorating building, in which the conveyance of sound has an electrical effect upon the nerves and energies of the workmen. Applying them to our dwellings and public buildings we may avoid the disagreeable resonance of sound which so often leads us to the conclusion that the very walls have ears. The principle of the telephone has impressed the race ever since man took up his residence in dwellings—the causes, and their avoidance or enjoyment, are but of the knowledge of to-day.—*N. W. Lumberman.*

MODERN AUTOGRAPHIC PRINTING PROCESSES.

By THOMAS BOLAS, F.C.S.

ALTHOUGH the lithographic method, as carried out in conjunction with the steam printing machine, forms, in the case of large commercial orders, by far the most convenient autographic printing process, there are innumerable occasions which call for the rapid production of small numbers of autographic prints. Of late years many very convenient methods of attaining this end have been devised; but before illustrating the more important of these to you, I should like to show you how simply and easily zincographic printing can be performed in an amateur fashion—zincography being similar to lithography, except that a zinc plate is employed in the place of the lithographic stone.

Here is a sheet of the so-called transfer paper, this being merely a moderately fine paper which has been brushed over on one side with a mucilaginous mixture prepared by boiling together the following materials: Water, 1,000 parts; starch, 100 parts; gamboge, 6 parts; glue, 1 part. I will now write on the transfer paper with the ordinary commercial lithographic writing ink, this having been rubbed up with water like an artist's water-color. The writing being now dry, it is necessary to somewhat moisten the back of the transfer by means of a damp sponge; after which it is laid, face downward, on a sheet of ordinary roofing zinc, this having been previously cleaned by means of emery cloth. Both being now passed together under the roller of this small press, you see that the transfer adheres to the metal plate; but on damping the back of the paper it becomes easily removable, leaving the writing on the zinc. The face of the zinc plate is now gently rubbed over with mucilage of gum arabic, which, by the bye, is all the better for being slightly sour; and the excess of gum having been sponged off, an India-rubber inking roller, charged with ordinary printer's ink, is passed over the still damp zinc plate a few times. The ink, as you may see, takes only on the lines of the transferred writing, and it is now merely necessary to lay a sheet of white paper on the plate, and to pass both through the press in order to obtain an impression—an exact reproduction of the original writing, as you see. Any number of copies can be printed by repeating the operations of damping and inking; while the zincographic process, as thus simplified, is rapid, economical, and within the reach of every one.

The lithographic process, as also the zincographic, is often used with great advantage in conjunction with photography, especially in those cases where the original writing was not executed in the saponaceous ink which is used for transference to the stone or the zinc. As I recently illustrated in this room the various methods of preparing a transfer by photographic means, it is not necessary to enter into any particulars at the present time. I have, however, placed on the table some stones bearing photo-lithographic impressions, together with some prints and transfers produced by the agency of photography.

I wish to call your attention to a very successful application of photography to autographic printing as regards long numbers. This small volume, called "Dramatic Notes," is a very readable little book, recently published by David Bogue; and the numerous illustrations therein would, at first sight, be naturally taken for impressions from wood blocks or other typographic printing surfaces. This is not, however, the case; the illustrations being, in reality, photo-lithographs, and they were printed on the sheets after the typographic matter had been impressed, blank spaces being, of course, left for them. It is very interesting thus to find photo-lithography in successful competition with block printing for book work. In this case the photo-lithographic work was executed by Mr. W. Griggs, of Peckham.

ELECTRO-CHEMICAL PROCESS.

For a long time zincography and lithography were, to all intents and purposes, the only autographic printing methods in use; if we except the ordinary copying process on thin paper, and Wedgwood's manifold writer; but neither of these requires consideration in the present communication. In the year 1871, Mr. E. de Zuccato introduced a process which he termed "electro-chemical printing," and I will proceed to illustrate the principle of this invention; although, as a matter of practice, it is now superseded by other processes.

Here is an iron plate which has been varnished over with a resinous varnish, and by means of a steel point I will trace through the varnish so as to lay the metal bare in places. The iron plate is now laid on the bed of a press, and some sheets of thin paper, moistened with a solution of potassium ferrocyanide, are placed on it. A copper plate being now put over the moistened paper, moderate pressure is applied. The iron plate is next connected with the carbon of a voltaic battery, while the copper plate which covers the moistened paper is connected with the zinc of the battery. Under these circumstances the iron dissolves at all these places where the varnish was removed by means of the style; and Prussian blue being formed by reaction with the potassium ferro-cyanide, parts of the papers become imprinted with blue characters, these corresponding exactly with the original tracings on the varnished iron plate. You see that the writing is imprinted on each of the sheets of paper used, and as the coloring matter goes quite through, the writing can be read from either side.

THE PAPYROGRAPH.

This method of printing was suggested by Bain's electro-chemical telegraph; and it has itself suggested to Mr. Zuccato another and simpler method of printing which he calls "papyrograph."

Here is a sheet of fine paper which has been saturated with a resinous varnish and dried. On it I now write with an ink consisting of a strong solution of caustic soda, slightly colored in order to be more obvious to the eye. The soda immediately attacks the resinous preparation of the paper, converting it into a soap. The sheet is now floated on water, the written side being upward, and the water soon penetrates the softened parts, making the written lines to stand up in bold relief as ridges of fluid. The paper is now removed from the surface of the water and pressed between folds of blotting paper, after which it is once more floated on the surface of the water and again blotted off in order to remove the remainder of the resin soap.

The sheet, thus prepared, forms a stencil of which the general ground is impervious to moisture; while the written lines, being denuded of varnish, are therefore quite porous, and they afford an easy passage to an aqueous liquid. In the early days of papyrograph printing, a pad, saturated with persulphate of iron, was placed at the back of the stencil, while the paper to be printed on was moistened with a solution of ferrocyanide of potassium. The iron salt being forced through the porous lines by a gentle pressure, reacted on the ferrocyanide; a blue impression was the result. It is now, however, found to be more convenient to print from the stencil by means of an aniline color dissolved in glycerine, and the coloring power of this kind of ink is so great that dry paper may be used for receiving the impression. Here, then, is a velvet pad which has been moistened with a solution of aniline blue in glycerine, and on it I lay the paper stencil, this having been previously brushed over at the back with a little of the ink. It is now merely necessary to place sheets of paper on the upper face of the stencil, and to apply gentle pressure by means of an ordinary copying press, in order to obtain copies rapidly and easily as you see. The copies can be printed off more quickly by this process than by typography or lithography, the comparison being of course made with these processes as worked at hand presses. About six hundred copies can generally be printed from one stencil.

Over at yonder table Mr. Perry is printing off papyrograph prints with great rapidity; and, although he has already obtained several hundred copies from the stencil which he is using, the present copies are quite as good as the earlier ones.

THE EDISON ELECTRICAL PEN.

Let us now pass on to the consideration of another class of printing stencil, this kind being made by the mechanical perforation of a suitable paper or tissue. Stencils perforated by a rapidly rising and falling needle point, actuated by a treadle, have long been used for the printing of embroidery patterns. In such a case, powdered color, mixed with resin, is dusted through the stencil, after which the device is fixed by the application of sufficient heat to soften the resin. Edison proposed to use such perforated stencils for ordinary autographic printing purposes, and he has ingeniously replaced the complex treadle perforating machine by a kind of pen in which a needle point is made to move rapidly up and down by means of a small electric motor attached to the instrument. As early as 1866, however, Huffman introduced and patented a portable perforating pen, the motive power in this case being clockwork contained in a cylindrical box attached to the upper part of the apparatus.

Here, then, is Edison's electric pen, and you see that when I connect the terminal screws of the electric motor with a battery of two elements, the needle rapidly passes in and out of the perforated point of the instrument. If I now write with it on a piece of black paper, this paper becomes perforated, and I can make the perforations obvious to you by using the perforated paper as a magic-lantern slide. In order that you may better understand the nature of the electric engine which drives the perforating needle of Edison's electric pen, I have placed on the table two models of electric engines which I will now set to work, and you can examine them at your leisure.

This sheet of ink-proof paper has been written on with the electric pen, and you see how easily it can be used as a printing stencil. I merely lay it down on a sheet of white paper and pass an inking roller over its back—you see that the ink, in passing through the perforations, has reproduced the original writing with great perfection; and the operation of printing is very rapid, so that many copies can be produced in a short time. Other perforating pens have followed in the wake of Edison's electric instrument, among which may be mentioned the horograph, a very convenient and portable clock-work pen, which is manufactured by Messrs. Newton, Wilson & Co., of Cheapside. Here is the instrument, and yonder are some specimens of work done with it. A pneumatic pen, in which the motive power is a stream of air supplied from a foot bellows, has also been introduced into the market. A still more complex and expensive arrangement than either of the preceding for producing perforated stencils, consists of an induction coil, capable of giving a sufficiently powerful spark to perforate the stencil paper; and this spark is made to continually pass between a partially insulated metallic pen and a metal plate on which the stencil paper is laid.

ZUCCATO'S LATE IMPROVEMENT.

All the above-described perforating arrangements have the disadvantage of being expensive, complex in construction, and liable to get out of order when used by unskilled persons, while the perpendicular position in which the mechanical perforating pens must be held necessarily hampers the freedom of the writer. These objections have been very completely overcome in a new perforating method recently introduced by Mr. Zuccato. In this case the impervious stencil paper is laid on a hardened steel plate cut on the face like a fine file, and the writing is executed by means of a point or style of hardened steel. Under these circumstances the teeth of the file-like plate perforate the paper wherever the point of the style exerts pressure, and a stencil eminently adapted for printing from is the result. Here is a small model of the apparatus employed by Mr. Zuccato for this kind of printing, and called by him the trypograph. I now lay a sheet of the prepared paper on the file-like plate and write with the hardened steel pencil, the operation of writing being as easy as if a black lead pencil were empioyed. Let us now fix the stencil on the frame of this little desk-like press, place a sheet of white paper underneath, and then push over the upper surface of the stencil an India-rubber scraper or squeegee charged with printer's ink. You see that the ink passing through the perforation has produced a copy of the original writing, while Mr. Neale, who is printing by this method at the other end of the table affords sufficient illustration of the rapidity of this method of autographic printing, by which as many as six thousand copies can be obtained from one stencil.

In order to illustrate to you the nature of the trypograph stencil I will project the image of one on the screen; and let us employ one made of sheet aluminum, thin metallic plates being readily perforated by Zuccato's method. You now will notice that the perforations are quite distinct from each other; although, when the stencil is printed from, the dots of ink so far flow together as to produce nearly or quite continuous lines.

Let us now project the image of electric-pen stencil on the screen, so that you can see the clear round perforations produced by the vibrating needle, and compare them with the results obtained by the trypographic method.

It may interest you to know that Mr. Zuccato has just found that calico receives the trypographic impression admirably, and he has executed some specimens which will now be passed round.

COLLOGRAPHY.

Mr. Pumphrey, of Birmingham, has introduced a method of autographic printing which he terms collography, and its working depends on the fact that when a film of moist bichromated gelatine is brought into contact with ferrous salts, tannin, or certain other substances, the gelatine is so far altered as to acquire the property of attracting a fatty ink. Mr. Pumphrey supplies plates of slate or glass covered on one side with a thin film of gelatine, and these are prepared for use by being soaked in a weak solution of potassium bichromate, all excess of moisture being then removed by first wiping with a cloth, and afterward rolling paper on the damp surface. A drawing or writing which has been made with either an ordinary iron and gall-nut ink, or with a special ink, is now transferred to the prepared plate, just as in the case of the transfer to zinc. The original being now removed, the plate is inked by means of a roller moistened by a sponge, in order to remove any trace of ink from the ground, and then printed from, much as if it were a lithographic stone, or a zincographic plate. I can hardly afford time to illustrate this process to you, but some prints on the table will enable you to judge of its capabilities.

We now pass on to the study of some methods, which are rather copying processes than printing methods, as they depend on the writing of an original with a very intense ink, and then dividing the ink so as to obtain a number of feebler copies. The ordinary method of obtaining one or two reversed copies of a letter on thin paper is of this nature, but it requires no description here; but those processes which are capable of yielding 30 to 60 fairly good copies depend on the use of a solution of an aniline color for writing, colors of this class being in general exceedingly intense. In the case of copying processes introduced by Pumphrey and Byford, the writing is executed with a strong solution of an aniline color on thin and tolerably hard paper, just as you see me doing now. You will see that the writing has quite penetrated through the thin paper, and on pressing a sheet of moistened paper against the back of the original, some of the aniline color will set off on the damp paper, giving a direct copy of the original writing. In the same way numerous copies may be produced; but processes of this kind cannot reproduce very fine lines with distinctness. A somewhat analogous arrangement for obtaining numerous copies is afforded by Waterlow's multiplex-copying portfolio and its contents. You see that I write with the aniline ink, and press down a damp sheet of very soft and porous paper on the writing. This soft paper absorbs a large proportion of the aniline ink, and itself forms a reversed printing surface capable of yielding a considerable number of direct copies to damp sheets of paper.

The above described copying processes all labor under the disadvantage of requiring the use of damp paper for receiving the impression, but the difficulty has been overcome in an arrangement which has been extensively sold under the names of hectograph and chromograph, these differing from each other rather as regards detail than kind.

The writing is executed on ordinary writing-paper with an aniline color ink, and when the lines have dried, the original is transferred to the surface of a slab of soft gelatinous composition, analogous to that used for making printers' rollers, contact being established by a gentle rubbing with the hand. The original, after being allowed to remain in contact with the gelatine slab for about two minutes is stripped off, leaving the greater part of the ink on the gelatine. To obtain the copies it is now merely necessary to lay paper on the slab and either rub down with the hand or establish contact by means of a soft roller. The requisite

number of copies having been obtained, or the color on the lines being exhausted, the slab can be cleaned by means of a damp sponge, when it is again ready for use.

The representative of the Hectograph Company, who is now printing, has executed a series of very artistically drawn prints in various colors, aniline color inks being, I believe, used in every case.

A composition for making the slab may be prepared as follows: One pound of gelatine is soaked in water until it becomes flaccid, after which it is melted in a water bath, with six pounds of common glycerine, the heat being maintained for a few hours so as to drive off all excess of water. The mixture is then poured out into zinc trays half an inch deep, and allowed to set.

The ink may be prepared by dissolving one part of aniline violet (blue shade) in a mixture of seven parts of water and one of alcohol.

Since the advent of the chromograph a multitude of similar articles have been sold under various names, in which, however, the terminal syllable "graph" has generally been retained. So numerous have these "graphs" become, that some enterprising individual, perhaps an American, has recently introduced into the market a "Lick-'em-all-graph."

Autographic engraving processes, such as relief etching on zinc, the grapho-glyphic process, and the production of autographic blocks by such an engraving machine as that of Shanks and Johnson, do not come within the scope of the present paper, as they would require to be treated of at considerable length; but Mr. Dallas, of phototypic fame, has kindly brought some admirable specimens of autographic printing done by his block process. Here, for example, is a reproduction of one of Mr. Gladstone's post-cards, and it is so well done as to be hardly distinguishable from the original.

PELLET'S PLAN FOR COPYING DRAWINGS.

Mr. Chapman has kindly lent me specimens of a photographic process especially adapted for reproducing engineers' plans, and it is likely to be of very great value to large firms who often require several copies of important and complex plans. This process was invented by the well-known French chemist, Pellet, and the original plans were drawn on tracing cloth or paper with an opaque ink. The original drawing is placed in an ordinary printing frame, and behind it is placed a corresponding sheet of the sensitive paper, this being supplied by the patentee ready for use; it is merely a stout paper coated with a mixture of perchloride of iron, an easily oxidizable organic matter. The printing frame being now exposed to light for a short time (one minute in sunshine being often sufficient), the persalt of iron becomes reduced to the state of protosalt wherever the sensitive paper is unprotected by the opaque lines of the original tracing. After removal from the printing frame the exposed sheet is immersed in a strong solution of potassium ferrocyanide, and this substance reacting with the persalt of iron remaining on those parts of the paper protected by the opaque lines gives rise to the production of Prussian blue, while the general ground of the paper remains white. It is now merely necessary to wash the print and to soak it in dilute hydrochloric acid in order to remove superfluous matter, a final washing being, of course, necessary to remove the free acid. The old ferroprussiate process which gives white lines on a blue ground found little favor with engineers, as the exposure required is long and it is naturally impossible to tint or color the prints. Neither of these objections applies to Pellet's process. I should like you especially to notice yonder copy of a working drawing of a locomotive engine, the sheet of paper on which it is executed being over five feet long, while the fineness of detail recalls a copper-plate engraving. To reproduce such a work by hand would cost more pounds than the photographic copy costs shillings, and even then there would not be the same certainty as to perfection of results.—*Journal Society of Arts.*

IMPROVED FILTERS.

For the purpose of filtering large quantities of liquids, such as sirups, wines, liquors, and solutions, particularly when it is desirable to prevent their prolonged contact with air, the method of upward filtration is highly advantageous. Such an apparatus is illustrated in Fig. 1. In some form or

FIG. 1.

another, it has been in use for a long time, but seems to be confined to certain classes of trades and manufactures foreign to pharmacy and chemistry, while it would, without doubt, frequently be used in laboratories. It scarcely needs a description, except to point out that the filtering medium at *a* may be any substance appropriate to the liquid to be filtered: either sand, charcoal, or tow, or chopped straw, etc. The liquid to be filtered may be introduced from a high level, under pressure, and the filtering surface will always remain clear, since the solid particles sink to the bottom. The screw is intended to tighten the filtering medium according to circumstances.

Another very useful filter is the so-called sugar-house, or Taylor's filter, a modified form of which we have described in our vol. for 1877, p. 199. A. W. von Babo, Director of the œnological and pomological school at Klosterneuburg, near Vienna, has lately described an improved form of this, which is illustrated in Fig. 2. The principal defect of the sugar-house filter was its tendency to swell out laterally, and if more than one was used at a time, they were liable to clog each other's filtering surface. This is overcome by the following arrangement. Over a pipe made of tinned iron (or other suitable material) and closed at the bottom, a rather wide bag is slipped, into the interior of which several equidistant hoops have been fastened, so as to distend the bag to its full extent at those points. The bag is then tied

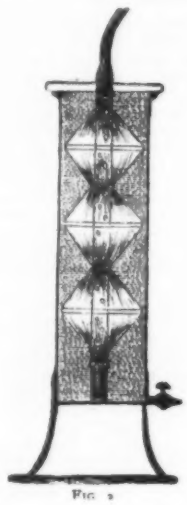


FIG. 2.

at the top, at the bottom, and midway between the hoops, to the tin-pipe. The latter is perforated with openings, but only where it is covered by the bag. The whole contrivance is then set into a suitable tank, provided with a faucet. The liquid to be filtered is introduced into the open end of the pipe, whence it flows through the openings into the bag, filters through the latter, and collects as a clear liquid on the outside.—*Die Weinlaube.*

MIRRORS IN PHOTOGRAPHY.

THE value of a large mirror in photographing interiors can scarcely be believed by those who have not employed this excellent aid. Dr. Hermann Vogel, during his voyage to Egypt, was one of the first to call attention to the uses to which reflecting surfaces may be used to light up objects for the camera, and was enabled by the aid of a few common looking-glasses to secure pictures which could not otherwise have been obtained. We ourselves have recently seen the mirror used with good effect by photographers in the depiction of machinery, and, beyond the matter of making the object appear rather flat, owing to the absence of shadows, the results were exceedingly successful. Mirrors of very large size and considerable power are now manufactured by Chappuis, of Fleet Street, a name no doubt well known to our readers, and it was a pair of these, about a yard square, that we saw in operation. They were cheap instruments of fluted glass, which, according to the maker, increases the reflecting power some 20 per cent. The mirror, in photographing, should never be set down at rest, unless it is employed as an intermediary and to throw rays on the instrument that is to illuminate the object. The assistant who holds the mirror may, if the object is small, be enjoined to hold the mirror as steadily as he can, but as he is at best a very unsteady holder, there need not be any fear of the rays being sharply rendered in the photograph. Where there is a large surface to depict, he should move the flare, not too fast, over the surface of the object, bringing into the light one portion after the other. In this way a very even exposure is secured, and we have seen lathes and steam-hammers standing in remote corners of grimy workshops depicted in quite a smooth and delicate manner. As we have said, there is an absence of shadow which gives the object something of an uncanny appearance, but as there is generally some other reason apart from an art aspect, in securing the photograph, this defect is rarely of importance. If the mirror is rested on the ground, the result is of course a sharply illuminated spot upon the object which is otherwise in deep shadow.—*Photo. News.*

[Continued from SUPPLEMENT, No. 224, page 3568.]

DYNAMO-ELECTRIC MACHINES.

IN two preceding articles we have explained the beautiful and simple illustrations devised by Monsieur Antoine Breguet in his researches upon dynamo-electric machines. The first of these dealt with general principles underlying all machines for generating electric currents by the rotation of conducting wires in a magnetic field. The second was devoted to the Siemens machine and the various possible systems, good and bad, of winding the wire upon the armature. We have now to approach by far the most important part of M. Breguet's work, and to explain his theory of the Gramme machine, the only theory which completely accounts for the action of the ring of iron in the armature. We shall in conclusion give some further considerations of extreme importance upon a fact known to all practical electrical engineers, but hitherto completely unexplained by theory, namely, that it is necessary to displace the commutator brushes of dynamo-electric machines from the position of symmetry, the angular displacement varying with the velocity of rotation, and with the work which is being done by the machine.

Suppose, first, that a wire bent in the form shown in Fig. 17, was placed upon the apparatus described in the preceding articles and illustrated in Figs. 4 and 8. Under what conditions can it rotate? If a current passes through this wire, it will ascend branches 1 and 3 and descend branches 2 and 4. It is clear that there will be a tendency to move 2 in an opposite direction to 1; hence the forces tending to drive the conductor round will be two couples acting in opposite senses, urging 1 and 4 in one direction, and 2 and 3 in the other direction round the axis. The couple 2 and 3 will be, however, the weaker of the two, since the length between 2 and 3 is less, and they are further removed from the most intense part of the magnetic field than are 1 and 4. The total force of rotation will clearly be the difference of the two opposing couples; and the arrangement, as it is, is evidently worse than the arrangement given in Fig. 4 of the first article. The rotation of conductors 1 and 4 is just *pro tanto* hindered by the opposing forces on 2 and 3. If only the action of the magnetic field on these two branches could be reduced to nothing, the effective force of rotation will obviously be increased. Now there is one way, and but one, to *screen off* the magnetic field from the branches 2 and 3, and that is by interposing a screen of iron in the form of a ring. To understand fully how the iron ring can act as a magnetic screen for the wires within it, it is

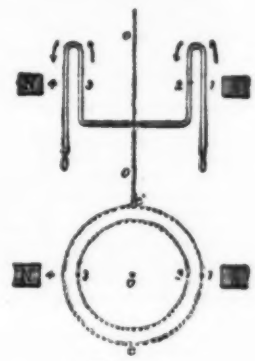


FIG. 17.

needful to comprehend the nature of magnetic substances in general in respect of their behavior as screens.

We have, in the first article, spoken of magnetic lines of force as Faraday defined them, and their properties. The most important of these properties in the present regard is that they pass by preference through a magnetic substance, which, so to speak, conducts them better. Iron is about a million times as magnetic as air, hence we find that the lines of force in a magnetic field are very greatly altered in form by the presence of a mass of iron, as they have a tendency to so arrange themselves that they may run as far as possible through iron and as little as possible through the air or the surrounding space. For example, if Fig. 18 represents

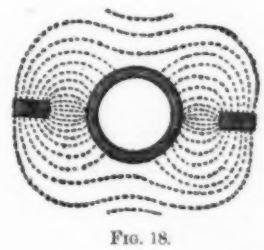


FIG. 18.

the magnetic "field" between two poles, N and S, in which also a hollow cylinder of iron has been placed, it is found, by the method of sprinkling iron filings over a card laid in the field, that instead of assuming the usual simple arcs passing across from one pole to the other, the lines of force are bent about in a remarkable manner. They curve round so as to meet the ring, travel along in the substance of the iron as far as possible, then emerge at the other side to curve round sharply into the other pole. *The entire space within the ring is destitute of the lines of force* and is thus screened off from magnetic influences. The interior of a hollow ball of iron is in like manner screened from all external magnetic influences; a property of which advantage was taken by Sir W. Thomson in the construction of certain galvanometers specially designed for use on board cable laying ships. The cylinder of iron in Fig. 18 would serve equally well as a screen to the interior portions whether at rest or in rotation round its axis, for even if rotating the lines of force would prefer to pass through the iron rather than cross the anterior air-filled space. The external field might be somewhat deformed in symmetry during the rotation, in consequence of iron requiring *time* to part with its magnetism, but this would not affect the interior space where no magnetic forces are.

It will be convenient for our purpose to consider the effects produced in the magnetic field by a cylinder of iron so short that it may practically be considered a *ring*. This is shown in section in Fig. 19. Here we may notice several points.

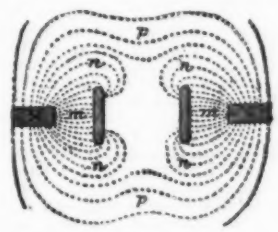


FIG. 19.

First the peculiar grouping of the lines of force. Most of them in the intensest parts of the field run straight from the pole to the ring, thence round through to the iron of the ring invisibly, and emerge again at the opposite side. These groups of lines, marked *m*, indicate that the magnetic force is concentrated into that part of the field immediately opposite the poles. Next, there are certain groups, *n*, of less intensity which pass above or below the edges of the ring to curve round into it on the inner edge, and which in like manner run round the substance of the ring and emerge at the opposite side. Lastly, there are some outlying lines of force marked *p*, which pass by above and below, and which are of no importance. It is particularly to be noticed that no lines cross the interior of the ring to go from one pole to the other, so that the ring still acts as a screen.

Now suppose such a ring to be placed within the bent conductor of Fig. 17, the arrangement will assume the form shown in Fig. 20, where branches 1 and 4 of the conductor

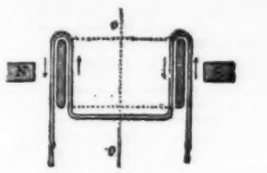


FIG. 20.

are exterior to the ring, 2 and 3 interior Clearly, as far as 1 and 4 are concerned, they are more advantageously situated than before, for the iron ring intensifies the portion of the magnetic field in which they are situated. As to the branches, 2 and 3, their condition is now wholly changed. They are chiefly screened from magnetic actions, the only lines that cross them being those of the groups, *b*, but these lines, instead of being merely lines of force running across from N to S, are lines which actually curve round and cross them as if coming from S to N. Consequently the magnetic forces on 2 and 3 act in the reverse sense to what they did when there was no iron ring, and the force of rotation acting on 2 and 3 now tends to spin them round in the *same sense* as 1 and 4. The model illustrating this beautiful theoretical demonstration of the part played by the iron ring was shown to the Société de Physique by M. Breguet at one of its meetings in 1879, and its performance was so perfect as to leave nothing to be desired. A further modification shown in Fig. 21, having four equidistant turns, is a still nearer

FIG. 21.

approach to the Gramme ring. It only requires that a coil of many turns should be substituted for each single fold of wire, and that the number of such coils upon the iron ring should be increased, to obtain the true article. In that case, however, the commutator pieces would be made of small are and proportionately numerous, as described in the preceding article. Up to this point we have treated the matter as if the Gramme armature were intended to rotate as in an electro-motor, converting an existing electric current into motion. The principle of *reversibility* laid down in our first article shows, however, that all the considerations advanced apply equally well to the case in which the motion of the armature in the field is employed to generate a current of electricity. As is well known the Gramme machine, besides being an admirable generator, is capable of being advantageously used as an electro-motor. It matters not, moreover, from a theoretical point of view, whether or not the iron ring is fixed, or rotates with the coils of wires upon it; though for practical reasons the latter is of course always the case.

We are now prepared to discuss the question whether the Gramme armature with its ring, or the Siemens armature with its longitudinally wound coils, is the more advantageous. It will be admitted that the only effective portions of the coils of the Siemens armature are the wires parallel to the axis of rotation, and that those portions which cross the ends radially are comparatively useless, as they cut few lines of force, and add to the total resistance. Also, in the Gramme armature the effective portions of the coils are those external to the ring, the wires along the screened internal face cutting few lines of force. Hence, given two rival machines having equally intense magnetic fields, equal velocities of rotation, and therefore equal electro-motive forces, that machine will have the advantage in which the shortest wire can be coiled into the greatest number of effective turns. It must be remembered that one turn of the Siemens armature corresponds to two turns on the Gramme armature taken at opposite points on one diameter of the ring. Hence, the calling the longitudinal dimension of either armature l, and its diameter d, the length of wire necessary to make one complete turn of the Siemens armature will be $2\,(l+d)$, while that necessary to make the equivalent two turns of the Gramme ring will be $4\,l$ (neglecting the thickness of the iron ring, which may be relatively small). Hence the Gramme will be better if $4\,l$ is less than $2\,(l+d)$; the Siemens better if $4\,l$ is greater. If $4\,l=2\,(l+d)$, or if $l=d$, then they will be of equal power. Hence it follows that of necessity the Siemens armature should be long in proportion to its diametral thickness, while the Gramme will be best if the diameter of the ring be greater than its thickness parallel to the axis. For reasons of construction it is also found advisable to make the rings of the Gramme machine flat wide rings rather than deep narrow ones.

We will now finally follow M. Breguet into his inquiry into the cause of the dissymmetrical position of the commutator brushes of dynamo-electric machines. Experience has dictated that, to obtain the best possible results, it is necessary to adjust the brushes which take the current from the commutator to an oblique position different from that dictated by theory. Moreover, the amount of this angular displacement is found to vary with different speeds of the machine, and with the work done in the circuit. Neglect of this matter leads to sparking at the commutators and consequent wear and waste. In the Brush machine and in the Weston and some other forms there is indeed a particular adjustment to enable the brushes to be set at will. Another point which has hitherto been quite unexplained is that if the machine were being employed as a generator of currents, this displacement of the brushes must be a lead or a displacement in the direction of the rotation, while in the case in which the machine was used as a motor the brushes must be displaced in the opposite direction to that of the rotation, or with a negative lead. In spite of these plainly incompatible conditions, it has always been customary to attribute the practice thus dictated empirically by experience to the slowness with which the soft iron of the armatures loses its magnetism, or, in other words, to the retardation of demagnetization. If we go back to the simplest of all the forms of movable rotating conductor we have considered, it will be apparent that the best moment for changing the direction of the current in the conductor is that instant when perpendicular common to the conductor and to the effective lines of force in the field passes through the axis of rotation. Thus, in Fig. 22, if the

FIG. 22.

lines of force ran straight across the field from pole N, to pole S, then clearly the best points to reverse the current would be at c and c_1, or on a diameter at right angles to N S. Now, up to this point it has been *assumed* that the magnetic field is symmetrical across between the poles, and that the greatest number of effective lines of force run across straight from N to S, or at least in gentle arcs symmetrically above and below the line N S. As a matter of fact, this is never the case, since the presence of the conductors carrying the vertical currents is sufficient to introduce serious modifications in the positions of the lines of force. Around the conductors which carry the electric currents there is also a "field" of magnetic force in which the lines of force are arranged, not radially as about the poles of magnets, but in concentric circles. The presence of the current then changes the total directions of the forces at work in the field, and throws the lines of force into new places. In fact, as mentioned in our first article, the principal lines running across the field from N to S will be distorted, as shown in Fig. 22, into an S-shape, illustrating unmistakably the tendency to move in opposite directions the conductors L^1 and L, in which the current is flowing in opposite ways. From the principle laid down above, it follows that the most advantageous position to reverse the current is, therefore, not along the diameter $c\,c^1$, but along the diameter $g\,g^1$, drawn at right angles to the chief line of force at the center. The angle between these two diameters is clearly the angle at which the contact brushes ought to be displaced in order that the current may be reversed at the most favorable moment. We are here considering the case where a current is being used to produce motion, that is to say, where the Gramme machine is being used *as a motor*. Now, the form of the S-shaped line will depend on the relative strengths of that part of magnetism in the field due to the field magnets, N S, and that due to the current. If the current is relatively weaker, the S-shaped curve will be more nearly a straight line; if the current be powerful (relatively to the magnets), then the line running from N to S will be a well-formed S. Now, this clearly implies that if the current is strong, relatively to the magnet, the angular displacement of the contact brushes, $c^1\,o\,g^1$, will be great, while, if the current is relatively weak, the displacement of the brushes will be small. Again, it is well known that when an electro-motor is running with a great velocity there is a reaction current set up in it in an opposite direction to that which produces the motion and tending to produce an opposing electro-motive force. If an electro-motor is allowed to run very rapidly this opposing induced current will reduce the supplied current to a fraction of its original strength. The maximum work is done by an electro-motor when this reaction current just halves the original current. Hence if an electro-motor whose armature is running in an invariable magnetic field be doing light work, and therefore be running very quickly, the reaction current will reduce the total current in the conductors relatively to the power of the magnets, and, under such circumstances, the displacement of the contact brushes will be small. If the motor be doing heavy work, and its velocity be therefore slow, the reaction current will be feeble and the total current strong in proportion to the magnets, hence the brushes must be displaced through a large angle. The rule, therefore, for dynamo-electric machines used as *motors* is that the contact brushes must be displaced in an inverse sense to that of the rotation of the armature, and with an angular displacement, which is greater as its velocity is less, or as the work done by the motor is greater.

Now consider the case where the machine is used as a generator. If the armature be driven round in the field mechanically, the current generated will be in the opposite direction to that of a current which we have supposed to produce a rotation in the same sense. Hence, if we think of the magnetic forces due to the current thus induced in the conductors, we shall see that they will produce a displacement of the lines of force in the field, but this displacement will be the converse of the former case; the chief line of force crossing the center of the field will be S-shaped as before, but will be reversed in position as compared with that shown in Fig. 22, and will pass from N above L^1 below L, and so to S. In this case the diameter of commutation, $g^1\,g$, will cross the line, $c^1\,c$, from right to left, and the contact brushes must be displaced in the same sense as the rotation of the armature, or must be set so as to have a true lead. Here again the question of the relative strength of the magnetic forces due to the current and to the magnets comes into play. If the field magnets be simply permanent steel magnets, or if they are electro-magnets excited by a current generated independently from another source, then the electromotive force in the rotating armature will be, as shown by the researches of Mascart and Angot, and others, simply proportional to the velocity of rotation. In that case, if the resistance of the circuit is constant, the strength of the current will also rise proportionally to the velocity and the deformations of the field, and hence the angular displacement of the contact brushes must be greater as the velocity is greater. The rule is, therefore, for magneto-electric machines, and for those dynamo-electric machines in which the field magnets are separately excited, when used as generators, that the contact brushes must be displaced in the same sense as that of the rotation and with an angular displacement which is greater as the velocity is greater.

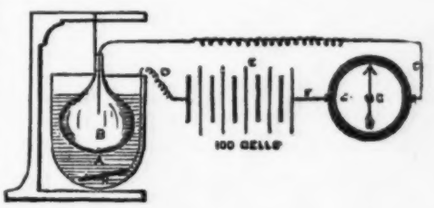
Finally, take the more common case where the field magnets of the dynamo-electric generator are excited by the current generated, or are included in the circuit of the machine. With small velocities before the electro-magnets have nearly attained their maximum magnetization, the strength of the magnets will increase as the strength of the current. Hence the relative intensities of magnets and of current grow almost at the same rate, and the displacement of the contact brushes need only be small. With greater velocities, however, and stronger currents, the magnets will begin to approach their condition of saturation, when any increase in the strength of the current no longer produces anything like a corresponding increase in the power of the magnets. Under such circumstances it is clear the deformation of the lines of the field will become greatly exaggerated, and the displacement of the contact brushes must be very great. M. Breguet tells us that with magnets too small in proportion to the armature, and with a velocity of 1,770 revolutions per minute, he has succeeded in obtaining conditions which necessitated that the contact brushes should have a lead of 70°. A simple calculation leads to the conclusion that for great velocities the tangent of the angle of the lead should be proportional to the number of revolutions per minute.

Before entirely quitting the subject, we will just state what part is really played in this phenomenon of dissymmetry of commutation by the tardiness of the iron ring in receiving or parting with its magnetism. The presence of the iron ring exercises two influences quite distinct from one another. First, since it requires time to magnetize or demagnetize it, it will necessitate that the contact brushes be displaced a little in advance of their theoretical position, or with an increased lead. This displacement, always in the sense of the rotation, will, therefore, diminish the total displacement where the machine is used as a motor, but will increase it where used as a generator. In either case, however, its influence is quite small. M. Breguet found experimentally that, even with the enormous speed of 1,770 revolutions per minute, the displacement due to this source did not exceed 10°. Secondly, the presence of the iron ring increases the intensity of the magnetic field, concentrating a greater number of lines of force in it, and, therefore, tending to reduce the deformation in its symmetry. This is a most important influence, and it will be seen that in the case where the machine is used as a generator the presence of iron in the armature tends to bring back the most favorable position of the contact brushes toward the position of symmetry—that is, tends to *diminish* the angular displacement which must otherwise be observed. The action of the iron of the ring is, therefore, absolutely the contrary to that commonly attributed to it; for, so far from necessitating a displacement of the contact brushes in the direction of the rotation, it absolutely serves to diminish, and that very considerably, the angular displacement necessitated by the dissymmetry of the magnetic field.

The researches of M. Breguet place the whole theory of the Gramme machine in a new and intelligible light. They not only clear up the discrepancies hitherto existing, but lay down the basis upon which all future dynamo-electric machines must be constructed. The part played by the iron ring as a magnetic screen comes now for the first time to light; and by the aid of the reasonings now put forward one begins to see the *rationale* of many details hitherto dictated only by empirical practice. It is to be hoped that practical electricians will not be slow in turning these careful and ingenious deductions to good account.—*Engineering.*

AN EXPERIMENT ON INDUCTION.

AT the last meeting of the Society of Telegraph Engineers, during the discussion of Mr. C. H. Wilson's paper "On induction in Parallel Circuits," Mr. Willoughby Smith described a very interesting experiment he had made with a bladder of gutta percha, which well illustrated the electrical and other qualities of that material. In an inverted glass shade, A, containing clear water, was suspended a bladder of gutta percha, B, filled with water; through the neck of the bladder was a copper wire, C, which was in contact with the water in the bladder. A copper plate, H, was immersed in the water in the glass vessel, and a wire, D, connected with it was attached to one pole of 100 Menotti battery cells, E. Another wire, F, from the other pole of the battery was connected to one terminal of an astatic mirror reflecting galvanometer, G, the other end of the galvanome-



ter being connected to the wire, C, passing through the neck of the bladder. The superficial area of the bladder immersed was 203·6 square inches, its thickness 0·00065 of an inch, and its total weight 32 grains. The bladder contained 12 lb. 14 oz. of water, and had been suspended in air for eight days before it was immersed. The absolute electrical resistance of the 203·6 square inches was 1487·6 megohms at the end of one minute's electrification, and of ten minutes it was 4103·8 megohms. The absolute electrostatic capacity was 0·2266 microfarad. Its behavior during the test was precisely the same as that of copper conductors insulated with gutta percha for telegraphic purposes when similarly placed. Mr. Smith is continuing the experiments with the view of determining a true unit for the electrical properties of gutta percha.

ELECTRIC LIGHTING IN LONDON.

THE Thames Embankment system of electric lighting has been extended to the Victoria Station of the Metropolitan District Railway. The station, we learn from the *Times* report, is 350 feet long, 50 feet wide, and 40 feet high. There are two platforms, each 15 feet wide, the railway space between them being 20 feet wide. There are ten lights in all, of which five are placed over the down platform, dividing the length into spaces which are unequal owing to the interference of constructive details. Over the up platform are four lamps, which alternate with the five on the other side so as to afford an equable distribution of light. The tenth lamp is placed centrally over the foot bridge which connects the up and down platforms. The lights are produced and maintained by the same steam engine which is maintaining the forty lights on the Embankment and the ten on the bridge. The engine is, therefore, now maintaining a total of sixty lights—a point of considerable importance. Of still greater importance, perhaps, from a scientific point of view, as the *Times* remarks, is the distance to which the present machin.

city is transmitting the current. The distance marked on the map of the District Railway between their station at Charing Cross and that at Victoria is 2,383 yards, or 1·354 miles. The length of wire between the two stations, however, owing to curves and losses necessarily attending the laying, connecting, and fixing, is about 1·65 miles. The whole circuit is thus equal to a length of 3·30 miles. The ten lights are on two circuits, and are maintained by the two spare circuits of the Gramme machine which supplies the ten lights on Waterloo Bridge. The loading wire is similar to that used on the Embankment, being a cable of seven strands of No. 19 B. W. G. copper wire, highly insulated. The wires are laid through the tunnel of the railway, being fixed against the walls. There is a switch arrangement at the Victoria Station, so that the lights are started and extinguished on the spot, and are thus locally under control. This new development of electric lighting means something more than that sixty lights are now being successfully maintained from a single engine of twenty horse power nominal. It means that very considerable distances have been bridged over, and that other things being equal, the application of electricity for illuminating purposes can be carried to distances from the source of power previously unbelieved in and by some unthought of.

RECENT WONDERS OF LIGHT.*

By W. H. PREECE.

I TOLD you the last time we met together that the principal object I had in view in these lectures was not to startle you with new wonders, but to endeavor to train your minds to observation and experiment, and to exercise what is called the scientific application of the imagination. The exercise of this power is a constant source of enjoyment and instruction; in fact, it supplies us with a library that is unwritten and without weight, and enables us at all times to find something to amuse and entertain ourselves.

Every science, of whatever branch, is always based on facts. Last week I showed you a few simple facts in connection with sound. I showed you how sounds, or sonorous vibrations, are conveyed and imparted to the brain. I showed you that a medium was required to carry these vibrations to the ear, and that the medium in the case of sound was the air. There is, first, something required to produce the sound; secondly, something to transmit the sound; and thirdly, something to receive the sound and impart it to the brain. In the same way with light.

Light, like sound, is a mere form of vibration; and, again, like sound, it requires some source to set this vibration going—some medium to carry the vibrations from their source to the receiver, and a receiver, viz., that exquisite organ, the human eye. I ought not to say the human eye, because animals and insects have eyes which are still more wonderful than that of man. I ought to have brought the subject of light before you first, because in that wonderful first chapter of Genesis, it is noted that the first thing created was light: "Let there be light; and there was light." But I gave sound the precedence, because I thought that by showing you the simple way in which sound is produced and transmitted, you would readily gather some notion of similar facts in regard to light. I have said that light is vibration; it is the vibration of that medium that fills all space called the ether. The process by which a ray of light is received on the eye through the medium of the ether is similar to that by which sounds are received by the ear. But the velocities of the two kinds of vibration are very different. You are all familiar with waves on water. These waves travel about a foot per second. The waves of vibrations of sound, I told you, travel at the rate of 1,100 feet per second. Light travels at the rate of 186,000 miles per second, and we may regard this speed (as I said in my last lecture, when speaking of a thunderstorm) as practically infinite. While the length of a sound wave produced by the voice varies between one foot and seventeen feet, that of light waves varies between the thirty-six thousandth and the sixty thousandth part of an inch. The fewest number of vibrations the ear perceives is sixteen per second, but nearly five hundred billions strike the eye. Of course it is impossible to grasp such figures as these with our minds, and it is only by constant thought, research, and ingenuity, that we can form some notion of the infinitely great and the infinitely little. Light, like sound, varies in itself in three ways, in quality, in intensity, and in pitch. The quality of the light is easily shown. We have the soft light produced by the sun burner in the center of the ceiling, that produced by the various lamps before you, and you are all familiar with the yellow light of the candle and the red hue of the fire. So all sources of light vary in different modes as regards their quality.

Here is a spirit lamp, which I bring alongside this gas burner, and you see the contrast—the blue flame of the lamp and the bright flame of the gas. Light varies in intensity. Here you see the mild light of the spirit lamp, and later I will show you the brilliancy of the light produced by electricity as compared with gas. The softest light is that due to phosphorescence, which is a case of vibration set up in certain bodies by light itself, and is seen sometimes in the sea when a vessel is plowing through it on warm summer evenings.

SEPARATION OF WHITE LIGHT INTO COLORS.

Sounds vary in pitch. Notes of music are produced by the different times with which the ear is struck. So in light the pitch depends upon the number of waves striking the eye per second. Light, as you are aware, as we experience it is white. But this apparently white light is made up of a bundle of other lights, as we see in a rainbow. In order to show you of what a white light is composed, I will ask for the gas to be turned out, and will cause a ray of white light to be thrown from a lamp on to the screen on the wall. There it is. You see the light burning in the lamp, and on the screen you see it as refracted, or passed through a prism of glass. The light as it passes through the prism is divided, and its rays are diverted by refrangibility, as it is called, and this refrangibility causes the white light proceeding from the lamp to be decomposed into its constituent parts, which appear on the screen in the different colors you see—red, orange, yellow, green, blue, indigo, and violet. I always remember the order in which these colors appear by repeating the sentence which I learned from Mr. Stokes, of "memory" renown, "Read over your good book in verse." You will never be at a loss to remember the order of the colors of the rainbow if you will only impress that sentence upon your memory.

Having shown you how light can be decomposed, I will now take the reverse process and show you the re-composition of light. Here is a disk on which the different colors of the rainbow have been painted. By causing this disk to revolve rapidly you will see that the colors, as it were, combine and make up what appears to you as a dull gray or dirty white light. This is the result of the rapid rotation of the disk, and the impression of the different colors painted on it upon the eye.

I dare say a good many of you have seen that pretty little light proceeding from a glowworm. Many of you, when at sea, may have noticed a beautiful, brilliant effect when the vessel has been rapidly going through the waves. This is caused by little insects, which give out the effect called phosphorescence. Those who travel abroad may have noticed in America those brilliant things flying about called fireflies. In all these cases light is produced, not by combustion, not by burning, not by the means that we are familiar with in our houses, but by the actual molecular vibrations set up by the action of light itself.

THE NEW LUMINOUS PAINT.

The new luminous paint illustrates this. I have several articles which have been coated with this new luminant. Here is a card, which I will expose to the light for a second or two, and now, on turning down the gas, you see that a luminous effect proceeds from the card. Mr. Horne (whose firm are agents for the inventor of the article) will now stand by a screen before you, and we will turn the light on him for a short time. There, now the gas is down, you see his shadow on the screen surrounded by the luminosity. Of course, as he stood between the lamp and the screen, his figure prevented the light from the lamp falling upon the screen; hence his figure or shadow appears dark, surrounded by the space upon which the light had fallen. This curious property has a future before it in various ways. For instance, not very long ago, I was traveling in the Mediterranean, and a poor French soldier, in the middle of the night, thought he would like a bath, and descended into the water; but the force of the waves was too strong for him, and he was instantly carried away. The ship was stopped and we went searching about for him for four hours, when we gave up the search in despair, and went on our journey. We had proceeded more than a mile or so, when we came across the poor fellow, who was thoroughly exhausted. We picked him up, but he died after a few hours. Now, if we had had a life buoy on board, coated with this paint, that could have been thrown to the man when in the water, and he would probably have been able to see it, and might have saved himself. I have two buoys here, one painted in the ordinary manner, and the other coated with the patent compound. The gas is now out, and I wave the two buoys backwards and forwards, and you can see only one of the buoys, and that because of the light given out by the paint. Here is a box containing glass tubes, in which various colors have been arranged. You will see that this kind of thing may be useful in a dark place by producing, as it were, a phantom spectrum. [Other articles were shown, such as surfaces, upon which words, "Danger," "To let," etc., had been marked out, and a few India-rubber balls, covered with the paint, were thrown among and quickly caught by the audience. Boxes of matches (given by Messrs. Bryant and May) on the ends of which paint had been placed, so that they were easy to find in the dark, were also distributed. The words, "Wonders of light," were also shown in the dark on the wall.] While we have the sun to rule us by day, and the moon by night, this new material may be useful to light up the dark spots in our domestic corners.

ARTIFICIAL LIGHTS.

From the very earliest days man has succeeded in producing light for domestic illumination. Striking two stones together produces light. Wax and tallow were the materials first used in the old time for lighting purposes. It is most remarkable that the means for producing artificial light were rough and uncouth even up to the beginning of this century. The ancients used oil in different forms; and, through the kindness of Sir Philip Cunliffe Owen, we have for exhibition here samples of lamps used by the Greeks, Romans, and Egyptians. In India the primitive kind of oil lamps are mentioned in the 25th, 27th, and 37th chapters of Exodus. To those who have visited Rome, one of the most interesting things to be seen is a sculpture on the Arch of Titus, showing the actual seven-branched candlestick that was constructed under the guidance and instruction of Moses.

CANDLE LIGHT.

In conservative Egypt, where we find all the manners and customs of the ancients carried out now as two thousand years ago, there we still find the same means of lighting in use as of yore. Coming to later times, we have the Saxons, and those who read Sir Walter Scott (and I hope every one in this room has or will), will find in his books many an interesting tale told of the habits of our ancestors, the Saxons. There we learn that they used long wax candles, not only for giving light, but also for telling them the time of day. These candles were marked at certain intervals, representing time, showing how much was consumed in a given time, and so telling the hour of the day. More than that, they also had little brass balls fixed into the wax, which, when the wax was melted a certain point, fell into a brass basin, causing a tinkle, and so announced the time. Through the kindness of Messrs. Field, I have several specimens of different kinds of candles. Here is one, used at the present day, called King Alfred's candle. It is marked off in spaces, one, two, three, etc.; and, as there are ten spaces, I take it the candle would last ten hours, and so you have a method of keeping time. The candles which King Alfred used were, I am afraid, of a rough manufacture, large in size, and from an artistic point of view, would compare very unfavorably with the elegant samples of the present day now before you, bearing his name. Candles of the present day are sometimes works of art. Here is one in the shape of Cleopatra's Needle, a monument in itself, but it has a wick down its center, and is made to burn, and not to be preserved. The light given by such a candle is a great contrast to that proceeding from a farthing dip. I remember the time when I used to be taken to bed with a farthing dip, or something very like one, with a piece of wire work around it, which was allowed to burn down, and the final smoulder of which gave off an odor of an almost unbearable nastiness which scarcely left my nostrils by next morning's rising time. Candles have been improved upon since those days, and now, instead of filling our rooms and houses with the horrid smell given off by the old form of farthing dip, we have an excellent light-giving composite candle which is odorless. The candles nowadays are made of purer matter than the tallow of old. But, even at the present day, in out-of-the-way places, the inns are still lit up by the old impure article. It is often a matter of surprise to me how our friends a hundred years ago lived. The poor of the present day live in brighter, cleaner, and healthier atmospheres than the very richest a hundred years ago. And those who amuse themselves by going to our National Gallery and seeing the pictures of the past, will notice in what a miserable existence our friends of old lived. The Haymarket Theater used to be lit by candles, and positively, until the year 1842, the lessees were restricted, by the conditions of their tenancy, from burning anything else, although gas came into existence in 1813.

OIL LIGHT.

Oil, of course, is a better luminant than candles, but it was only in the last year of the reign of Charles II., in 1684, that oil was introduced into the City of London; and, in those days, there were people opposed to the introduction of any kind of light. Also, when oil was first introduced for street lighting in London, as I have said, it was only allowed to burn from six o'clock in the evening to midnight, from Michaelmas to Ladyday. It was in the bad light and bad smell of bad oil and nasty tallow that our ancestors had to spend their time in their drawing rooms and theaters. True they had wax, but wax was used but very little, and if you look at Hogarth's picture of "Marriage à la Mode," you will find that about two wax candles were used then to about twenty now. Here is a duplex oil lamp, giving off a light which many a Roman would have given his fortune for. Here is a moderator lamp, invented by Carcel, in which the oil is pumped up from a reservoir by mechanical action. Here is a Silber lamp, where the wick is supplied with oil by gravitation, and here is the soft steady light produced by a reading lamp.

For those who are interested in lamps, I am able (through the kindness of Messrs. Gardner) to put before you one of these lamps cut in two, which shows the mechanical skill that has been brought to bear even in our household lamps. A winding up clockwork arrangement is set in motion, which pumps up the oil by mechanical action, so that it shall flow gently over the wick, and maintain (as you see in a similar lamp on the table) a brilliant and clear light.

BRIEF HISTORY OF GAS LIGHT.

Gas was introduced at the commencement of this century in 1802. It is a magnificent thing in itself; but one of the greatest advantages of gas has been that it has driven the candle makers and oil lamp makers to give us a hundredfold better things than they did before; and so the introduction of electricity, if it does nothing else, will compel our Suggs and gas engineers to produce gas lighting apparatus as far superior to those of our youth as these ordinary lamps are to the oil lamps of the Greeks.

Murdoch introduced gas in 1802. The manufactory of Boulton and Watt was lighted up by it. Through the kindness of Mr. Sugg, I can show you the manufacture of gas from the commencement to the end.

When I was a boy at school, we often used to be left in the dark. At such times we resorted to the practice (which I dare say every boy among us is familiar with, and which is one of the earliest experiments I ever performed) of making gas with a tobacco pipe. It is called the first retort. I have a pipe here which has been filled with coal, and the open end of the bowl sealed up. After heat has been applied to the bowl, smoke issues from the stem, and on applying a light a flame is produced, which is gas. This pipe was made for smoking, and not for making gas evidently, as it has burst. However, the experiment is very simple, and we will pass on. Experiments are always very uncertain, and so frequently fail, that when a lecturer is successful in two out of three he is happy. There is a tale that Murdoch and Fairbairn were going to dine somewhere in the neighborhood of Manchester one night, and they had to cross a dark and dismal moor. So Murdoch made some gas, filled a bladder, and put it under his arm like bagpipes; he then placed a tobacco pipe at the mouth of the bladder which he held tightly, and having applied a light to the tobacco pipe, started on the journey with a light which took them across the moor. Gas, as you know, is manufactured from coal; and here I have a working model of a complete gas manufactory.

Coal is placed in the retort (which, in reality, is nothing but a better form of my pipe bowl), beneath which there is a flame. The flames heat the retort containing the coal, till the latter goes off in a thick heavy smoke, leaving behind coke. That smoke is gas, but in its present state it is charged with tar and other matters. It passes into what is called the hydraulic main, in which is placed a water valve that prevents the smoke from going back again, and collects the tar. Through this hydraulic main it proceeds to the condenser, through which water is slowly percolating, which carries away the tarry portion not left behind in the main. The hydraulic main, as I said, retains the tar. Passing through the condenser, the heavy smoke (as those near can see) comes to what are called scrubbers, which contain pieces of coke through which the gas passes, leaving behind it the impurities not taken out in the main or condenser, and from which it issues in an invisible form. It is not clean yet, but it here takes the invisible form. It is still charged with carbonic acid and sulphurets of different forms. It then passes through a purifier, consisting of lime, which extracts the carbonic acid. It then goes through a second purifier, containing oxide of iron, which has the property of extracting the sulphurets, principally sulphide of hydrogen; and now it is thoroughly purified, and passes into the gas holder, from whence it is pressed through the main and issues at the burner, where I have applied a light. If I put a little weight on the holder, you will see how I can add to or diminish the pressure issuing at the burner. It is by pressure of weights on the "holders," that gas is forced along the mains through the streets and into our houses.

Next to the manufacture of gas, we have to consider the mode in which it is burned. On a bar here are fixed various kinds of burners that have been introduced since the production of gas. There are the Cockspur jet—the first one ever introduced; next, the old "fish tail"—the fish tail is made by the gas passing through two little holes in the burner; Webster's; old iron bat's wing; Wadsworth's; Brönner's; hollow top, which consumes a large quantity of gas, and is, therefore, only used for large spaces; the old iron Argand; the Bray; the Albert; shadowless; and Sugg's London Argand. The Argand takes its name from the inventor. It succeeds in extracting from gas more light than the common form of burner. The Albert is the burner that has given such satisfaction in our streets, offices, and houses. But the large London Argand brought out by Mr. Sugg is the greatest achievement. It has taken the wind out of the sails of some of our electrical people, and shows how the streets of London can be lit up with a light of intense brilliancy. Here is one fitted up complete, and on lighting you see the splendid light produced. It is equal to 200 candles, which, in reality, is a light not far short of some of the electric lights. Here is another new process, called the albo-carbon. It is a little jet of gas, consuming about one foot

* A recent juvenile lecture delivered before the Society of Arts, London. For lecture on Recent Wonders of Sound, by same author, see SUPPLEMENT No. 217.

per hour, and, in the round box above it, there is one of the refuses of the gas manufactory called naphthaline. As the gas comes from the main or meter, it passes through this naphthaline, which increases its brilliancy many times. We have an ordinary burner close by for comparison, and the effect of the naphthaline on the one burner is very evident from the increased brilliancy of the light.

Before leaving this point, I ought to show you a fact that every householder should be acquainted with, and that is, that the quantity of light given off by our burners depends very much on the pressure with which it is forced through the jet. Some time last year there was considerable correspondence in the newspapers about gas bills. Many householders found to their astonishment that their gas bills were doubled. This simply arose from the fact that the gas companies, for purposes of their own, increased the pressure through the main; the result was, that, instead of burning gas at about eight-tenths pressure, that force was very much increased. To equalize such variation of pressure, a regulator becomes necessary, either at the meter or burner, which will allow the gas to be consumed without waste. To illustrate this, Mr. Sugg has kindly drawn up the diagram before you. Gas enters with a normal pressure of eight-tenths of an inch. Upon an unregulated burner, such pressure gives a light of 5·9 candles; on a regulated burner, the same quantity would give a light of 15·29 candles. If the pressure be gradually increased on an unregulated burner, the light would be increased, but not in equal proportion; and if we went up to a pressure of 1·7, we should only get a light of 9·1 candles, as compared with the normal pressure, 0·8, with lighting power of 5·9 candles. From this point the proportional increase of light diminishes with the pressure, and if the pressure on the main were increased to two inches, the light power through an unregulated burner would only be 6·6 candles. So that between one and two inches pressure we only gain two-tenths of a candle in lighting power, while the consumption of gas increased from 5·8 to 8·9 feet per hour. In other words, if your gas bill cost £58, it would be increased, under the high pressure, to £89, with scarcely any appreciable increased light. Mr. Sugg's regulator counteracts this extra pressure, and the adoption of it will, in a very great measure, dispel the recent alarm. Let, therefore, those householders who take knowledge of their gas bills, look to their burners and regulators.

HEAT AND LIGHT IDENTICAL.

All these illuminating effects that I have shown you have been due to flame. What is this flame? I have shown you candles, oil lamps, and gas, and in each case flames are produced. I will show you what a flame is. Here is a single candle where we have combustion going on. Heat is produced, and something burned. Now what is being burned in that candle? If I pass a white clean card through the flame gently, you will see in a very short time that something is deposited. This deposit is carbon in a very fine form. Therefore, to produce flame, there must be something to be burnt, and something to burn it with. Heat and light are identical. The greater the light the greater the heat, and the whole question before us of producing a good light is to produce an intense heat; the best illuminant is dependent on our being able to concentrate the greatest heat on the smallest quantity of matter. To produce flame matter is required. Here is a pale blue flame, and you see on my blowing matter into it, in the shape of lycopodium, I am able temporarily to enlarge the flame enormously. But I want to increase the heat. Here is a piece of coal. I will just set it burning, and throw upon it a stream of oxygen. This oxygen being pure, intensifies the action of combustion in the coal, which increases the heat produced, and, in consequence, we get a much brighter and more beautiful light. Here is a common flask which contains oxygen. I put into it a piece of carbon, and you see at once that the oxygen combines with the carbon and produces that violent motion you see going on. The intensely brilliant sparks given off are really beautiful. Here is a piece of magnesium which, on the application of a light, burns with great intensity in the atmosphere, and, consequently, the light given is brilliant and dazzling.

ELECTRICAL LIGHT.

As I said, to produce intense light we must have intense heat, and to maintain this intense heat we must call in the aid of electricity. There are many ways of producing electricity. One way is by making wires turn very rapidly in front of a magnet. Here is a little machine that consists of a magnet with a coil of wire inside. By turning the handle I rotate the coil very rapidly, and produce electricity, which appears in the form of heat in the illuminated tube on the table. Also I produce electricity by the consumption of zinc in a battery below, and on joining the two wires attached to that battery to the platinum wire suspended over the table, you will see it illuminated; and on my increasing the power of the battery, the heat in the wire becomes more intense, till finally it is severed. That wire is platina-iridium, and you noticed the beautiful soft glow it gave off. That is the principle upon which all electric lamps of the incandescent kind are based. Here is another kind of lamp which is produced by what is called the electric arc. This is the first form in which the electric light was discovered in 1806 by Sir Humphry Davy. Here are two pieces of carbon joined to a battery, and you see, when I hold them near each other, the electric current bridges over the space, forming a brilliant white light, which is called the electric arc. Here is an electric lamp based on the arc principle, the two pieces of carbon being regulated at the proper distance by clockwork; it is called the Serrin lamp. The electric current passing from one carbon to the other carries with it a mass of small particles of carbon, which it raises into an incandescent state, producing heat, and thereby light. This carrying away of particles from one of the carbons, of course, causes it to waste gradually away at a greater rate than the other carbon, and much ingenuity and skill have been brought to bear on the point to produce some means by which the uniform consumption of the carbon can be guaranteed. There are specimens of several kinds of electric lamps of this character on the table, which are very interesting. But one of the most ingenious systems is that of Jablochkoff, which dispenses entirely with complicated machinery in the lamp by making a "candle." This candle consists of two rods of carbon separated by plaster of Paris. These lamps are fitted with four candles, each of which burns for two hours, and as one goes down another is brought into play, so that eight hours' continuous light is given off by the lamp before fresh carbons are required. This particular kind of candle is really an arc, although, to a certain extent, it becomes an incandescent light, because the particles of matter between the ends of carbon assume a very high temperature.

I will now show you an electric arc reflected on the screen. There you now see the two carbon points very close together. The positions of them are reversed to those of actual practice, on account of the reflection. You will now notice the carbons approach and actually touch, but are again instantly separated. This was due to a slight interruption of the current from some cause, but on recovery, as it were, of the current, the carbons separate, and you can observe the process of combustion going on. The light that fills this room is that given off by the lambent flame you can see surrounding the arc; and it is the arc itself which gives off the intense heat producing the flame and light. On close inspection, by reflecting the light in this manner, you can trace out the formation of the light in all its minuteness, even to the little globules that are formed in its production.

To return to the Jablochkoff light. Through the kindness of the Société Generale d'Electricité, who are employed in London in lighting up the Thames Embankment and many other places, we have two wires from their place beneath Charing Cross Bridge brought to this room. The engine which is now pumping electricity for the illumination of the Embankment is also pumping electricity up to us through the two wires I have mentioned, and I will now ask Mr. Berly to throw these currents of electricity into the lamps that are fixed in this room. There, as you see, he merely turns a handle, and instantly the electricity that has been formed underneath Charing Cross Bridge is brought to this room, and acting upon lamps, similar to those I have explained, it produces the brilliant light now filling the room. The light is so intense that the effect of turning the large gas sunlight in the center of the ceiling on and off is scarcely noticed, and we are now in a cold brilliant light that does not vitiate the atmosphere, and one that is doubtless destined to do great wonders; but undoubtedly its greatest benefit will be to force our Suggs and gas engineers into activity to give us better gas and better burners. The light produced varies with the strength of the current.

ELECTRICAL LIGHT AND GAS LIGHT.

A great deal of nonsense has been talked about electricity and about gas. We have been startled lately by telegrams from the other side of the Atlantic; and to those who can read those telegrams properly, they announce nothing but the most outrageous nonsense. We have a correspondent of one of our papers telegraphing across the Atlantic that an electric lamp has been produced, which gives for 10d., a light equivalent to ten thousand cubic feet of gas. Now, ten thousand cubic feet of gas, where I live, cost £1 10s., and to produce anything in the form of an electric light which would do as announced, would certainly be a great wonder. But in the first part of this selfsame telegram, it is said that Mr. Edison has produced a light which gives only 16-candle power, and that one horse power will maintain eight of these lights going. To some this may seem a very extraordinary fact, but to us, who know something about gas and electricity, it is by no means so; for we know that in this city of London we are, at this moment, producing ten times the amount of light per horse power by electricity. Siemens produces in his machine exactly ten times the power of the light recently produced in New York. But more than that, gas itself does just the same as this vaunted light, if not more. The amount of coal consumed in producing one horse power—three pounds weight—will produce 142-candle power by gas. So that taking Mr. Edison's machine of one horse power as maintaining eight lights of 16-candle power each, producing a total of 128 candles, the startling announcement in its result comes out actually below the candle power in gas produced by the same quantity of coal; and hence this wonderful discovery that sends our gas stock down, I don't know how many per cent. is really worse in candle power than the gas we burn in London.

However, electricity will certainly have its day. It produces a brilliant and beautiful light. Those who go to the British Museum can read and study under a light as soft and brilliant as that of daylight. There are halls and buildings where gas is injurious to health. For instance, at the General Post Office we have, in a large gallery, over a thousand people at work at a time, and when all the gas burners are going, five million cubic feet of air are vitiated every hour, and of that figure four-fifths are vitiated by the gas. Now, if the electric light be used in that gallery, and the injurious vitiation by the gas prevented, you can see at once what a great hygienic improvement will be affected. I have not the slightest doubt that the introduction of electricity for lighting purposes will not be to the detriment of gas, because the chief value of gas is its heat producing property, and while the electric light may sweep off, as it were, a certain excrescence of the present method of employing gas for lighting, gas will be brought into our homes and houses for warming and heating purposes to a much greater extent than at present.

There is another point connected with electric lighting, and it is, that in showing you the electric light in this tube I used the muscular power of my arm. In the shed beneath Charing Cross Bridge there is a steam engine, and there the heat of the coal produces steam in the boiler, which produces motion in the engine. The motion of the engine produces electricity in the machine, and this electricity is transmitted by wires to various places, and there produces heat and light, and so we have a complete interchange of the forces of nature. But we are not dependent upon steam engines. Water may be used. Windmills and waterfalls are available for the purpose. Dr. Siemens has suggested that the Falls of Niagara might be utilized to light up New York; and, at the present moment, Sir William Armstrong uses a waterfall in his grounds, near Newcastle-on-Tyne, to run one of the wondrous machines, producing currents of electricity which supplies light for his library.

In giving you these two lectures, especially the one tonight, I have, I know, omitted a great many things that I might have said. I have several experiments on the table unperformed, but we always have a great enemy on these occasions, and that great enemy is Time. It is very difficult in a succinct and clear course to bring these rather complicated facts before you, except by taking them step by step from the earliest and simplest elementary forms to those in which they have been skillfully and practically applied. It is much better, if one wants to know these things, to find out for one's self, as I have said, from practice—by experiment and trial. Reading is very soon forgotten, but facts that are brought to us by trial, by zeal, and experiment, are invariably fixed indelibly upon the memory. There is something extremely interesting in all these scientific pursuits, and especially when we find that the applications of science are brought even to our very doors, and have become matters of daily use. Science itself, in all its branches, leads up insensibly from that which is tangible to that which is intangible; from the real to the ideal. But to the mind that is properly constituted, one of the great advantages of even a slight knowledge of a branch of science like this, is that it leads one insensibly "through Nature up to Nature's God."

A NEW STANDARD OF LIGHT.*

IN the pamphlet before us we have a proposal for a new form of standard light, and the author has shown some considerable skill in drawing out his method of producing it. We cannot do better than quote his opening paragraph as showing the requisites of a standard that the author deems necessary. He says:

"No exact measurement of any quantity, even with the most accurate and sensitive test measures available, can reasonably be expected unless the standard by which the unknown quantity is to be gauged is perfectly constant in itself; or if nature does not permit of such a desirable state of things, the causes to which the variation of the standard are due should be known, and in addition also, their quantitative effect on the standard, in order to be able to introduce a correction whenever accuracy of measurement should permit and circumstances necessitate it."

The want of a standard of light has long been felt in physical researches, and the British Association has acknowledged the impossibility of obtaining scientific measures with the ordinary standards, and has appointed a committee to consider the question of fixing such a standard of white light, that a unit of light may be capable of accurate definition.

It must not be forgotten that up to quite recent times the principal necessity for a standard at all has arisen through the introduction of gas into our dwellings and streets, and it has only been necessary to adopt one which should give the comparative illuminating powers of any variable qualities of gas. In fixing such a standard the points to be looked at were (1) that the standard should be capable of easy and exact reproduction; (2) that the color of the light should be approximately the same; and (3) that in varying states of barometric pressure and temperature, proper corrections in the results of the comparisons should be feasible. It will be seen further on that a fourth desideratum should be introduced for scientific work. Perhaps on no subject has more attention been paid to small details than in the production of a standard candle, and as a result, when burnt under proper conditions, it gives fairly correct values of the illuminating power of gases.

In the record of Mr. Schwendler's experiments with the standard candle as against his new standard of light, we have some startling variations in the light of a standard candle, but we feel sure that, had the proper conditions been observed there would never have occurred such a tremendous difference as 72 per cent. We are more convinced that ordinary precautions could not have beeen rigidly observed when we find that some of the comparisons were made after the candle had been freshly lighted. In gas photometry it is well-known that the standard candle should burn at least a quarter of an hour before it can be considered to have settled down to a steady light. The standard candle, however, is not a nice unit of light; and two years ago Mr. Vernon Harcourt introduced to the notice of the British Association a gas standard which seems to meet every requirement. By making a mixture in a small gas holder of one part of the most volatile spirit from American petroleum which distilled at 50° C. with 600 of air, or seven of the vapor with twenty of air, he produced a gas which, whilst almost insoluble in water, was permanent at all ordinary temperatures and pressures, and which was of a known composition and easy of manufacture. A jet of such a gas could be compared with the ordinary coal gas, and any variations affecting the one would equally affect the other. The colors of the standard and coal gas lights are also approximately the same. It seems that a standard of such a character meets the requirements for comparing the illuminating value of different coal gases.

Mr. Schwendler proposes to use the light radiated from platinum foil, when raised to incandescence by an electric current, as a new standard, and we agree that a solid instead of a gaseous body as the source of illumination is a step in the right direction. The standards made, however, appear to have been used for determining the illuminating value of the light produced by dynamo-electric machines under varying conditions of speed of armature and resistance in circuit, and it is in reference to this that we will first judge of its probable effectiveness, since for gas measurements the standards already existent suffice. Some dynamo-electric machines are advertised as generating the light of 50,000 candles, and we will suppose for the moment we are comparing such a light with Mr. Schwendler's standard.

Now it may be safely said that a standard candle, farther away than twenty feet from the photometer, would give too small a light to be practically of use as a standard, while if approaching the photometer within one foot the magnitude of the illuminating source would seriously affect any accurate results. In the first case the electric light would have to be about 4,500 feet away from the photometer and in the last about 220 feet. For ordinary photometric work even the least of these distances would be objectionable. The platinum standard employed by Mr. Schwendler is only about 0·7 of a standard candle, and these distances would have to be increased nearly 20 per cent.

For practical measurements of this description a candle power of fifty candles is a far preferable value, which it would be difficult to attain by the method proposed. In this case we have the distances reduced, and if the electric lamp is fixed at a distance of one hundred feet, we have the movable standard ranging between twenty feet and three to four feet, and the readings become easy and are not subject to be seriously affected by the magnitude of the illuminating source; in fact, the errors of observation then become of larger magnitude than any error arising from this cause. Another point which we have to note is that as far as the color of the light from the platinum standard is concerned, it possesses very little advantage over the ordinary gas or candle flame, and it would be impossible, or at all events incorrect, to give the illuminating value of a light such as of that produced by the electric arc in terms of the new standard; some recent experiments have demonstrated that the red light emitted by one square mile of the hollow crater in the positive carbon is equal to about the red light radiated by 40,000 standard candles, whilst the mean green light of the former is equal to the mean green light of about 135,000 of the latter, and until such a time as the relative physiological values of green and red light are accurately known it will be impossible to give any true estimate of the illuminating power of the electric light by ordinary photometric comparisons. Both in magnitude and color, then,

* On a New Standard of Light. By Louis Schwendler. From the Journal of the Society of Bengal, vol. xlviii. Part ii., 1879.—*Nature*.

the proposed platinum standard of light seems to fail for measuring light produced by high temperatures.

We now turn to the details of the lamp itself. We have, first, a U-shaped piece of thin platinum-foil cut out about twenty mm. in total length, each limb of the U being about three mm. in breadth, the tops of which are clipped in thick metal clips. The usual arrangements are made for passing a current through this foil, the amount being registered by a galvanometer in circuit. A glass shade is also employed for steadying the light, by keeping off convection currents. There seems to be an objection to this form of lamp for accurate scientific work, where it may be necessary to use an *image* of the source of illumination. For instance, in certain spectroscopic comparisons of different lights only a small portion of the image of the incandescent platinum would fall upon the slit. Now the first difficulty that would be met with would be as to the part of the platinum that would emit a standard light. Near the contacts the heat would be conducted away so rapidly that the color of the light would be of a different tint.

Again, presumably near the middle of the limbs of the U-shaped foil the temperature would be slightly higher than at the outsides; in fact, no two portions of the foil would be exactly at the same temperature.

For work, then, of this class, the standard seems to fail in an important particular.

The writer of this notice made many experiments on this point some years ago, and it was this objection that led him to abandon the idea of the platinum standard light of a form somewhat similar to that of Mr. Schwendler.

For a standard perfectly suited to scientific work, perhaps the following definition will be found tolerably exact: It should be a body (solid or liquid), some known area of the surface of which can be kept at a high constant temperature. It seems probable that a combination of a body of good with one of a bad conductivity will eventually be found to offer suitable materials for a really trustworthy standard.

It would be unjust to conclude this notice without paying a testimony to the great value of the experiments which have been carried out by Mr. Schwendler in this research. It is quite possible that a modification of his platinum standard may be constructed which will eliminate the defects which are to be found in it. It is certainly a step in advance of the gas or candle standard for everything beyond merely technical work, but it is not of the same accuracy as other scientific units.

W. A.

ON NEW LUMINOUS TUBES.

By M. TREVE.

THE author introduced a Fizeau condenser into a large Geissler tube. The two poles of the induced current of a Ruhmkorff coal were placed in contact with this condenser by means of the ordinary electrodes of such tubes. When the induced current is passed into the condenser, the tube still containing air at the atmospheric pressure, the ordinary snorting sound is heard, which gradually becomes fainter as the vacuum is made. When the pressure is reduced to 0·004 m. nothing is heard, but there appears a white and brilliant light, absolutely distinct from the pale, vague, phosphorescent light of Geissler tubes.

POWERS OF EYEPIECES.

THERE are various instruments for gauging the magnifying powers of the eyepieces of telescopes, but unless in skillful hands, they are all more or less attended by certain difficulties. The object of the following is to render the operation not only easy, but absolutely perfect.

The usual method is to apply the dynamometer to an eyepiece attached to a telescope, and by gauging the diameter of the little image or circle of light formed just outside the former, ascertain the power by dividing the diameter of the object-glass or speculum, by that of this little circle. But it is not always convenient to get a telescope of any considerable size into the best position for this purpose, and then a very small circle is not the easiest object to measure with absolute certainty.

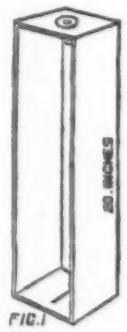
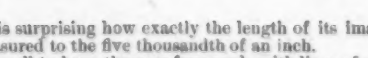


FIG. 1.

Now a very simple expedient may be adopted by all who wish to know what power they are using, and an inexpensive instrument for this purpose should be in the study of all who indulge in astronomical observations, of which the following is a description.

Take, or make a box 20 in. long, and about 6 in. in its other dimensions, entirely open on one side, Fig. 1. Make a hole in one end, and set it upon the other; provide a card to fit the lower end inside, and to the middle of this card attach a narrow slip of black paper (the border of mourning note paper will do) say 4 in. long, then place the eyepiece to be measured in the hole, and use my V dynamometer, and by dividing 4 in. by the ascertained length of the image of the black line, you have the power of the eyepiece on a focal length of 20 in., whence its power upon any other number of inches may be ascertained by simple arithmetic.

Let the black slip or mark be pointed at each end thus—



and it is surprising how exactly the length of its image can be measured to the five thousandth of an inch.

It is well to have three or four cards with lines of various, but exactly measured lengths, two, three, four, etc., inches, and always to use the longest that the eye-hole will admit of. The V dynamometers are made and sold by Mr. John Tuck, of Romsey, and any one can make the box.—*E. L. Berthon, in Eng. Mechanic.*

FLOW OF VISCOUS MATERIALS—A MODEL GLACIER.

THREE or four years ago an experiment was arranged by Mr. D. Macfarlane and myself for the purpose of showing the flow of a viscous mass and for illustrating glacier motion. The experiment then commenced gave rise to others of a similar nature. These experiments have proved so interesting that I venture to describe some of them to the readers of *Nature*.

Shortly after his discovery of the true nature of glacier motion, the late Principal Forbes was much pleased when one of his students, now the Rev. C. Watson, of Largs, showed him a quantity of shoemaker's wax which had been gradually flowing down on the bottom of a vessel accidentally left on an incline. Forbes was delighted with the wax, and considered it an admirable illustration of viscous flow. This was told to me in conversation some four years ago, and it occurred to me that a pretty illustrative glacier might be made with shoemaker's wax, and we proceeded to construct it. The model glacier has been shown year after year to the natural philosophy class in Glasgow, and has proved interesting and instructive beyond expectation.

A little wooden ravine was constructed, with a number of steep declivities and precipices and some more gentle slopes. There is one place, also, where the ravine is narrowed by projections inwards, which nearly meet each other. At the upper end of the ravine there is a flat part, on which ordinary shoemaker's wax is piled—as where snow collects at the upper end of the natural ravine; and from this collecting ground the material flows down steadily through the ravine, giving on a small scale a most perfect display of the flow of a semi-solid material. At the beginning of each winter session a supply of shoemaker's wax is given at the top, and, during the session the flow goes on slowly and steadily; hardly perceptible from day to day, but progressing from week to week and month to month. Every one knows what a brittle substance shoemaker's wax is at ordinary temperatures. A lump of it allowed to fall on the ground flies into a thousand pieces.

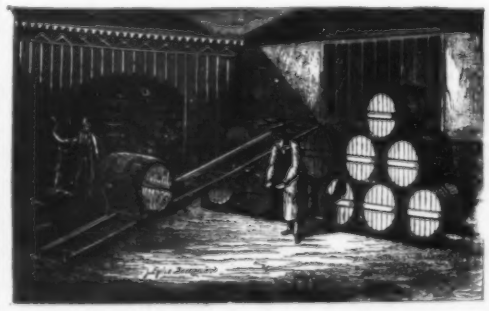
Watching this brittle apparent solid flowing down an inclined plane, brings very vividly before the mind the real nature of the glacier's flow. To imitate on the small scale Forbes' celebrated experiment of planting a row of stakes in the glacier, in order to compare the flow in the middle with the flow at the edges—the experiment which really established the fact of *viscous* flow—I have sometimes put a row of dots of white paint across our pitchy glacier. In a few days the more rapid motion of the middle portion, and the less rapid motion of the parts near the edges, is made apparent. There are others of the glacier phenomena which are also beautifully imitated by the shoemaker's wax. Little crevasses are sometimes formed, though not very often, owing to the great effect of temperature on the plasticity of the material; and the cross markings that are noticeable at the foot of a glacier are brought out extremely well.

Last year Sir William Thomson commenced a new and curious experiment on shoemaker's wax as a viscous material. A large circular cake of it about eighteen inches across and three inches thick was made. This was put into a shallow cylindrical glass vessel, which was filled with water to keep the temperature from varying with any great degree of rapidity. Below the cake a number of corks were put, and on the top there were put some lead bullets. The result has been that in a year the corks have floated up through the wax, and are coming out at the top; the bullets have sunk down through the wax, and have come out at the bottom; and this, it is to be observed, has gone on while the wax was at all times in such a condition as to be excessively brittle to any force suddenly applied, such as a blow from a hammer, or such as would be occasioned were the cake of wax to be allowed to fall on a stone floor.

J. T. BOTTOMLEY.

MECHANICAL SKID FOR RAISING CASKS AND OTHER PACKAGES.

THE annexed engraving shows a rapid and safe method of raising to any desired height, in a store or cellar where help is lacking, as many casks or packages as one may wish. The apparatus is very simple, and was invented by M. Flesselle, of Epernay. It consists simply of two parallels of wood maintained firmly in position by means of cross-stays. At the upper end there is a horizontal roller which, through a pitch chain, is made to revolve by means of a windlass and crank placed at such a height as to make it convenient for working. A ratchet attached to the crank allows a momentary stoppage to be made at any point. The hauling rope, by



FLESSELLE'S MECHANICAL SKID.

winding around the upper cylinder, causes the ascent of a car, whose rollers follow the parallel tracks, and are so constructed that they cannot leave them. This car carries a V-shaped frame, hinged on its back axle. By tilting this frame, one of its sides touches the ground so that the cask or package may be rolled on it with but little effort. The frame then being turned back to its proper position, the load is ready for raising. An ingenious system of levers prevents accidents of any kind, so that should the rope break, through long wear, the descent of the load would be at once arrested. The axle of the roller or upper drum is provided with a toothed uncoupler worked by a hand lever, and when the roller is rendered free on its axis the car descends by its own weight, without the necessity of using the crank. With this apparatus one man can pile up 44-gallon packages to a third, fourth, and even a fifth row without danger, and take them down just as easily by the same means. The apparatus, which weighs only 185 lb., is quite portable, and will be found very convenient for raising merchandise out of cellars, and for loading casks, boxes, bags, etc., on freight cars and trucks.

PRECAUTIONS IN COMPARING WEIGHTS.

DEVILLE AND MASCART, in explaining the construction of the international geodetic standard, give an interesting account of some of the necessary precautions. During the long series of operations upon which a comparison of two weights is based, a balance should never be opened. Its cage, composed of two envelopes of glass, bordered with cloth, should be guarded from the external air, which would change the hygrometric state of the interior, and which would introduce dust. The particles of dust notch the knife edges and change the velvet linings of the weight boxes into a material comparable to emery paper. Air may be forced into the interior at the rate of 4 or 5 liters (4·227 or 5·283 qts.) per hour, being first deprived of dust by filtration through cotton, and dried by chloride of potassium or other desiccatives. The substance which seems to produce the least wear on alloys of platinum and iridium is ivory, which has the further advantage of resisting moisture and other atmospheric influences, as is shown by cave fossils. The standard weights should, therefore, be kept in glass cylinders, with ivory caps at top and bottom.—*Comptes Rendus.*

THE FUNCTION OF CHLOROPHYL.

THE following is a more detailed abstract of the very important communication recently referred to in *The Month* as having been made to the Berlin Academy of Sciences, by Dr. Pringsheim, which appears to throw considerable fresh light on the function of chlorophyl in the life of the plant.

Having been led by previous researches to the conclusion that important results might be obtained by the use of intense light, Dr. Pringsheim contrived an apparatus by means of which the object under view should be brightly and constantly illuminated by a strong lens and a heliostat. If in this way an object containing chlorophyl—a moss-leaf, fern-prothallium, chara, conferva, or thin section of a leaf of a phanerogam—be observed, it is seen that great changes are produced in a period varying from three to six or more minutes.

The first and most striking result is the complete decomposition of the chlorophyl; so that in a few minutes the object appears as if it had been lying for some days in strong alcohol. Although, however, the green color has disappeared, the corpuscles retain their structure essentially unaltered. The change then gradually extends to the other constituents of the cell, the circulation of the protoplasm is arrested; the threads of protoplasm are ruptured and the nucleus displaced; the primordial utricle or ectoplasm contracts and becomes permeable to coloring substances; the turgidity of the cell ceases, and the cell presents, in short, all the phenomena of death.

That these effects are not due to the action of the high temperature to which the cell is exposed under these circumstances, is shown by the fact that they are produced by all the different parts of the visible spectrum. The result is the same whether the light has previously passed through a red solution of iodine in carbon bisulphide, through a blue ammoniacal solution of cupric oxide, or through a green solution of cupric chloride. If the carbon bisulphide solution of iodine be so concentrated that only rays of a greater wave-length than 0·00061 mm. can pass through it, these effects are not produced, although about 80 per cent. of the heat of white sunlight is transmitted. On the other hand, if the ammoniacal solution of cupric oxide be so concentrated that the whole of the waves of a less wave-length than 0·00057 mm. are absorbed, a rapid and powerful effect is produced, although the amount of heat that passes is very small. It is thus shown that the phenomena in question are not the result of heat.

The next point determined by Dr. Pringsheim is that the effects are not produced in an atmosphere devoid of oxygen. This was the case whether the oxygen was repiaced by pure hydrogen or by a mixture of hydrogen and carbon dioxide; while the removal of the carbon dioxide from atmospheric air was altogether without effect on the phenomena. The conclusion drawn is that the decomposition of chlorophyl in the living plant is a process of combustion, which is influenced and promoted by the action of light, and which is not related to the decomposition of carbon dioxide by the plant. When the green color of the chlorophyl-grains has been partially destroyed, it cannot be restored, even though the cell continues to live; from which it is inferred that the result is not a normal physiological, but a pathological effect. No substance was found in the cells which might be regarded as the product of decomposition of the chlorophyl, nor was any oil or starch detected in the etiolated cell, nor any formation of grape sugar or dextrin. The assumption is therefore that the products of decomposition are given off in the gaseous form.

The conclusion is drawn that the decomposition produced in the protoplasm and in the other colorless cell contents is the direct effect of the photochemical action of light. That it is not due to the injurious influence of the products of decomposition of the coloring matter of the chlorophyl is shown by the fact that it takes place equally in cells destitute of chlorophyl, such as the hairs on the stamens of *Tradescantia*, the stinging hairs of the nettle, etc. It is, on the other hand, dependent on the presence of oxygen, or is a phenomenon of combustion.

The result of a variety of experiments leads Dr. Pringsheim to the important and interesting conclusion that the chlorophyl acts as a protective substance to the protoplasm against the injurious influence of light, diminishing the amount of combustion, or, in other words, acting as a regulator of the respiration.

He then proceeds to investigate what are the substances which become oxidized in the process of respiration. In every cell, without exception, that contains chlorophyl, Pringsheim finds a substance that can be extracted by immersion in dilute hydrochloric acid for from twelve to twenty-four hours, to which he gives the name *hypochlorin* or *hypochromyl*, and which he believes to be the primary product of the assimilation of the chlorophyl. It occurs in the form of minute viscid drops or masses of a semi-fluid consistency, which gradually change into long red-brown imperfectly crystalline needles. It is soluble in alcohol, ether, turpentine, and benzol, but insoluble in water and in a solution of sodium chloride. It becomes gradually oxi-

dized on exposure to an imperfectly crystalline resinous substance It is probably an ethereal oil and an invariable accompaniment of the coloring substance of chlorophyl, and even more universally distributed than starch or oil. It has not yet been detected in those plants which do not contain true green chlorophyl, such as the Phycochromaceæ, Distomaceæ, Fucaceæ, and Florideæ. Starch and oil appear to be reserve substances, produced by the oxidation of the hypochlorin under the influence of light; it being the most readily oxidizable constituent of the cell, more so even than the chlorophyl itself.

That the hypochlorin is present in variable quantity in every chlorophyl grain under normal circumstances, and is subject to continual increase and decrease, may be proved without difficulty. All comparative observations on chlorophyl grains in younger and in older conditions point unmistakably to the conclusion that the collection and increase of the starch inclosed in the ground-substance of the chlorophyl goes on *pari passu* with a decrease of the hypochlorin. In dark the hypochlorin, which does not take any direct part in the transport of food materials, is more permanent than starch; and this again is in agreement with the conclusion that its transformation in the cell into more highly oxidized bodies is hindered by the increased respiration in light.

In the facts here described and the conclusions derived from them, Dr. Pringsheim believes that an entirely new light is thrown on the cause of the well-known fact that assimilation takes place only in those cells of the plant which contain chlorophyl, and only under the influence of sunlight. This substance acts universally as a moderator of respiration by its absorptive influence on light, especially of the red rays, and hence allows the opposite phenomena of respiration and elimination of carbon dioxide to go on in those cells which contain it. A more detailed account of the experiments and results is promised by the author in a future paper.

THE "EGASSE" DISINFECTANT.

THIS disinfectant is said, by *Les Mondes*, to fix instantly all the gaseous or liquid bodies which, in a mass of putrescent organic matter are the sources of all infections. In addition, it can be used as a remedy for the stings of insects, for the destruction of phylloxera and other vermin, for the preservation of timber, etc. As a disinfectant its power is asserted to be sixteen times greater than that of phenol, fourteen times greater than that of cresylic acid, etc. No light whatever is thrown upon its nature and composition. It must be noted that in the account of this disinfectant, carbonic acid is classed among the "deleterious miasms" escaping from cesspools.

ON THE SOLUBILITY OF SOLIDS IN GASES.*

By J. B. HANNAY, F.R.S.E., F.C.S., and JAMES HOGARTH, F.C.S.

THE research which we now have the honor of submitting to the Royal Society, and of which a preliminary notice was published in the Society's "Proceedings,"† was instituted with the view of throwing some further light upon what Dr. Andrews calls the "critical state" of matter. In his famous Bakerian lecture, after a very careful discussion of the question, Dr Andrews says :‡ "Carbonic acid at 35·5° C., and under a pressure of 108 atmospheres, stands nearly midway between the gas and the liquid, and we have no valid grounds for assigning it to the one form of matter any more than to the other." This conclusion is based on the relation of volume to pressure for different temperatures, and on the failure of optical tests to show any distinction between gas and liquid when pressure is applied above the critical temperature. It occurred to us that some knowledge might be gained by examining the solvent properties of some fluid for a non-volatile solid in the passage of the solvent from the liquid to the gaseous state. The property of dissolving solids being supposed peculiar to liquids, it seemed to us that on passing through the critical state there would be a precipitation of solid, or if, on the other hand, no separation occurred, a further proof of the perfect continuity of the gaseous and liquid states would be presented. To put the matter to a test, a solution of potassic iodide in alcohol was prepared, and a strong tube filled to about one-half with the solution. After sealing, the tube was placed in an air-bath and heat applied. No precipitation of solid could be seen, even at a temperature of 350° C., more than 100° C. above the critical point of alcohol.

For the examination of the phenomena of solution some form of pressure apparatus was necessary, so that the volume of the fluid experimented on might be altered at pleasure. After several experiments we adopted a modified form of Dr. Andrews' apparatus, which allowed us to change an experimental tube in a few minutes, and showed no sign of leakage at the highest pressure reached. It is made of wrought-iron tubing, such as is used in hydraulic machinery, about half an inch internal and one inch external diameter. The length of the apparatus is nine inches, and there is a side tube welded on, measuring about three inches, for the insertion of the manometer tube. On the ends of the tube are screwed strong caps, also of wrought iron; through one of these the pressure screw works, the others serve for the admission of the experimental and manometer tubes. The distinguishing feature of the apparatus is the packing for the screw and tubes. It consists of a solid plug of India-rubber, about half an inch thick, placed in the hollow cap, so that it serves both for packing the screw or tube and for making the joint between the cap and the iron tube tight. To prevent the pressure screw from cutting the India-rubber, a lining of thin leather, well soaked in lard, was placed between it and the rubber. The tubes were similarly packed, and to keep them from being forced out through the aperture in the cap, a thickening was made in the glass by fusing and pressing together, and between this bulbous part and the iron a strong leather washer was placed. In some cases, when a very high pressure was wanted, the tube was cemented in with oxychloride of zinc, which effectually prevented it from coming in contact with the iron cap. With this mode of packing the pressure screw did not require to be very fine, the one commonly used being one-quarter of an inch in diameter and screwed thirty threads to the inch. The only limit to the pressure was the frailty of the glass tubes; we have, however, attained a pressure of 880 atmospheres, as shown by an air manometer, and even at this enormous pressure the screw could be freely removed in either direction without leakage. The apparatus was as tight with mercury as with water, so that there was no necessity for using two liquids, as in Dr. Andrews' machine. When a high temperature was required the experimental tube was bent over, as shown in the drawing, and passed into an air-bath formed of two concentric iron cylinders. The cylinders had mica windows, through which the experiment could be observed, and, to insure perfect regularity of temperature, the inner one was lined with cement about half an inch thick. As in most of our experiments, it was quite unnecessary to know the pressure; a simple straight tube was used instead of the T shaped one described. It was screwed to fit the same caps, and, from its simplicity, made a very convenient and efficient apparatus.

The experiments with the sealed tube showed us that no deposit of solid occurred above the critical point. With the assistance of the apparatus just described we were able to show a crystal of potassic iodide dissolving in alcohol gas (using the word gas, as Dr. Andrews proposes, for a fluid at any temperature above its critical point). Having fixed a tube (internal diameter 0·75 mm., external 7 mm.), in the apparatus previously filled with mercury, some alcohol was sucked in by gradually withdrawing the pressure screw. By a further withdrawal of the screw the little thread of alcohol was moved inward past a constriction made in the glass tube near the end, and a small fragment of fused potassic iodide dropped in so as to rest on the narrow neck. Sufficient heat was now applied to boil the alcohol and expel the air, and the end of the tube strongly sealed with the blowpipe. The tube being placed in its position in the bath, heat was applied, and the pressure regulated so as to keep the alcohol from passing round the bend into the other limb of the U-tube. The tube and its contents were thus raised to a temperature of 300° C. (the critical point of alcohol, as will be shown, is 234·4° C.), the crystal never having come in contact with the liquid alcohol. Pressure was now applied until the alcohol was reduced to about the volume occupied by it while still liquid, when the fragment of iodide was seen to dissolve gradually and completely. On withdrawing the screw slowly no deposit occurred, even when the volume was very considerably increased, but, by taking off the pressure very rapidly, a crystalline film appeared on the glass, and in some cases a cloud of fine crystals, floating in the menstruum. These crystals could be easily redissolved by again increasing the pressure. The deposit most frequently occurred just at the surface of the mercury, and this we ascribe to a local rarefaction caused by the slightly higher temperature of the mercury. The fact of the existence of solvent power above the critical point being established by this experiment, we next sought to examine the phenomenon by using other solvents and solids. The sealed tube method was found most convenient for this purpose, an experiment with the pressure apparatus being resorted to when we wished to vary the volume. The tube was filled from half to two-thirds with the solution to be tested, and by a few experiments the strength of the solution was so adjusted that no separation of solid took place, when the tube was completely filled by expansion.

The behavior of a solution of potassic iodide we have already described. Bromide of potassium gave a similar result. The solubility of chloride of calcium in alcohol was found to be uninterrupted by the passage of the alcohol through the critical state. Cobaltous chloride (anhydrous) remained in solution at 320° C., the highest temperature reached in this experiment, and the beautiful blue color of the solution was unimpaired. Ferric chloride (sublimed) gave a yellow fluid at a temperature of 260° C. This yellow color rapidly disappeared, and a reddish-colored powder separated out, which remained insoluble on cooling. On opening the tube a strong ethereal odor was perceived. This was most probably due to the formation of ethylic chloride. Some peculiar phenomena observed when heating the ferric chloride solution deserve description. At a temperature of 120° C. a very strongly colored liquid layer appeared at the bottom of the tube, while the uppermost layer was perceptibly paler. As the temperature rose the two layers gradually mixed, and the fluid was quite homogeneous at and above the critical point.

A solution of ferric chloride in ether was distinctly colored at least 30° C. above the critical point, but the color gradually faded, and did not return on cooling. The separation and redissolving of part of the ferric chloride occurred also with ether.

A solution of sulphur in carbon disulphide showed no separation of sulphur when raised 50° C. above its critical point. Of course sulphur at this temperature is a liquid, but its vapor tension is comparatively so small that its solution is worth recording. Selenium also remained in solution in carbon disulphide above its critical point, and separated out in part when the solution cooled. Chemical action evidently took place in this experiment, for on evaporating a portion of the solution after heating a reddish yellow residue containing selenium was obtained. The liquid had a distinct horseradish smell, and, on burning, gave a dark stain on a piece of porcelain held in the flame. Sulphide of selenium was most probably formed. An attempt was made to dissolve cadmic sulphide in carbon disulphide, but without success. In an experiment with metallic arsenic and carbon disulphide the arsenic seemed to dissolve; but as an orange-colored film appeared on the glass on cooling, we are inclined to doubt its solubility. When some sulphur was inclosed in the tube with arsenic and carbon disulphide, and the temperature raised above the critical point, solution occurred, and when the temperature was allowed to fall a separation of dense liquid drops took place at the critical point. At a lower temperature these solidify and form reddish yellow crystals. The apparent solubility of arsenic was thus probably due to its conversion into a sulphide, and the subsequent solution of the sulphide formed.

Carbon tetrachloride was also tried as a solvent; but as the number of substances soluble in this fluid is very small, we can only record a few negative experiments. Cupric chloride did not dissolve, but appeared to be acted on chemically above the critical point, its color changing to brown. Chromic chloride showed no sign of solution. Zinc oxide did not dissolve, but at a temperature of 20° or 30° above the critical point a sudden chemical change occurred, and, as a result, the critical point was found to be lowered from 280° C. to about 200°. On cooling some transparent globules were seen, and on opening the tube there was an outrush of gas. The transparent globules dissolved in water, and were found to be chloride of zinc.

The use of water as a solvent was quite out of the question, both on account of its high critical point and the corrosion of the glass tubes, so that we were debarred from the use of the liquid whose examination promised most.

The mixture of light paraffins known as paraffin spirit was tried as a solvent for some organic substances. A solution of resin in this liquid remained perfectly bright and without sign of separation at a temperature of 350° to 360°, almost 100° above the critical point.

The examination of liquids to determine their critical temperature and pressure was not exactly in the line of our research; but as Cagniard de la Tour's numbers, so far as we are aware, are the only ones on record, we have made a number of experiments in this direction. To obtain accurate measurements of pressure is a matter of very great difficulty, and as for our purpose these were not required, it would have made our research unnecessarily tedious to attempt it. Our numbers are as follows:

	Alcohol.	Carbon Disulphide.	Carbon Tetrachloride.
Mean temperature.....	234·6°	272·96°	277·9°
Number of experiments..	47	12	4
Probable error of a single experiment.....	2·06°	1·34°	0·69°
Mean pressure.....	65 atmos.	77·9 atmos.	58·1 atmos.
Number of experiments..	14	12	4
Probable error of a single experiment.....	1·0 atmos.	1·5 atmos.	0·55 atmos.

The alcohol used had a specific gravity of 0·7949 at 15·5° C. In the carbon tetrachloride experiments the mercury was attacked, but our numbers were taken as quickly as possible, and before chemical action had taken place to any great extent.

Cagniard de la Tour gives the following results for alcohol and carbon disulphide:

Alcohol.....	158·7° C.	119·0 atmospheres.
Carbon disulphide..	275·0° C.	77·8 "

The differences between Cagniard de la Tour's numbers and our own in the case of alcohol are no doubt due to the difficulty of obtaining that body anhydrous. As will be seen from the density given, the alcohol used in these experiments contained only a very small quantity of water, and was, indeed, practically anhydrous.

To determine whether the presence of a solid in solution affected the critical temperature and pressure, a cold saturated solution of potassic iodide in alcohol was prepared. Experiments with this solution gave as the average of these trials—temperature 237·1 C., pressure 71·1 atmospheres. The probable error of a single experiment is for the temperature 0·37 C., for the pressure 0·5 atmosphere. The exact amount of solid present in solution when the readings were made it was impossible to determine; for in altering the volume so as to observe the critical point, a small quantity was deposited on the glass just at the end of the mercury column. To make sure that some salt did remain in solution, we brought the mercury column up so as to cover the crystalline film, and, after carefully examining to see that no solid particles were above the mercury, we allowed the fluid to cool under pressure. When cold the end of the capillary was broken off, and the liquid, which had been shut off by the mercury from contact with the crystalline deposit, received in a watch-glass. On evaporation it gave an appreciable residue. These experiments seem to show that a liquid has its critical point raised by the solution in it of a solid.

As the solubility of potassic iodide in alcohol is very slight (1 part in 40 at 13·5° C.), we thought it advisable to try a solution of chloride of calcium in alcohol, so that the effect of solution on the pressure and temperature might be shown in a more marked degree. On heating a cold saturated solution of calcic chloride (anhydrous), a dense liquid layer was observed to form at the bottom when the temperature reached 230° C.; at 240° C. the line separating the lighter layer of liquid from vapor was very indistinct, and could not be distinguished at all above 250° C.; at 255° C. the dense layer dissolved, but reappeared when pressure was taken off. When the volume was again reduced it redissolved, and at 270° C. expansion caused a deposition of crystals. In this experiment there was no sharp critical point, and no pressure readings were taken. A dense layer, it will be remembered, was also noticed in the ferric chloride experiment. A combination of the chloride with part of the alcohol evidently occurs, and at a higher temperature diffusion takes place until the fluid is quite homogeneous.

While working with cobaltous chloride an interesting question presented itself to us: Is the absorption spectrum of a substance dissolved in a fluid above its critical point the same as in liquid solution or in the solid state? To answer this question a solution of anhydrous cobaltous chloride was sealed in a tube as before, and its spectrum observed while heat was applied. No change could be detected in its passage through the critical point, and a careful comparison of the spectra of the same solution at 15° C. and at 300° C. showed no difference beyond the fainter and more nebulous character of the bands caused by expansion. The position of the bands was not changed. Chloride of cobalt, however, was not well fitted for our purpose, the measurement of the bands being rather uncertain on account of the nebulous nature of their edges. At the suggestion of Prof. Stokes, we turned our attention to the product of the decomposition of chlorophyl by acids. The beautiful spectrum of a solution of this body in alcohol was quite permanent, even at a temperature of 350° C., although when heated in air it decomposes below 200° C. A direct comparison of the hot and cold solutions failed to show any change in the position of the lines.

A good opportunity of testing the question further seemed to be offered by the blue solution of sodium in liquefied ammonia, described by Gore.* To prepare this we first tried compression of the gas by the pressure apparatus, but the quantity of liquid got by this method was too small for experiment. We next tried a combination of Gore's method with pressure apparatus. A tube, shaped as in the drawing, had the wide part charged with chloride of calcium saturated with ammonia, and the end sealed. By applying slight heat the air was expelled by the liberated ammonia. A small piece of sodium was then placed in a pocket near the end of the experimental tube, and, after sealing, the tube was placed in the pressure apparatus and surrounded with mercury. The iron tube was now heated by flaming with a Bunsen, and the experimental tube cooled in a freezing mixture. Distillation of ammonia commenced, and when a sufficient quantity of liquid was obtained the pressure screw was advanced, until, coming in contact with the wide tube, it broke the narrow neck joining it with the experimental tube, and allowed the mercury to rush in and inclose the liquefied ammonia. Further pressure brought the ammonia in contact with the sodium and solution commenced, but an unforeseen difficulty caused the experiment to fail, for the sodium solution coming in contact with the mercury was rapidly decolorized by it. It was therefore necessary to dispense with the use of mercury. Several methods were proposed, and we finally arrived at the following simple and effective one: A piece of tubing, about

* Extracts from a paper read before the Royal Society, February 26, 1880.

† "Proc. Roy. Soc.," vol. xxix., p. 234.

‡ "Phil. Trans.," 1869, p. 588.

* "Proc. Roy. Soc.," vol. xxi.

one-quarter of an inch diameter, was joined to a piece of marine barometer tubing, and just beside the join the latter was drawn out to an exceedingly fine bore. The wide tube was now charged with ammonia-saturated chloride of calcium and the end sealed. A small piece of solid paraffin was then dropped into the capillary tube so that it lay next the drawn-out portion. When all air was expelled by heating slightly, a few fragments of sodium were placed in the tube, and the whole sealed. The end containing the sodium being placed in a freezing mixture, the wide tube was carefully heated until sufficient ammonia was distilled over. When re-absorption commenced the fragment of paraffin was melted by the application of a very small flame, and capillary attraction caused it to run into the fine bore, where it solidified and prevented any passage of ammonia. The tube now containing a solution of sodium in ammonia was next cut off near the join, and the end sealed in the blow-pipe flame, the paraffin plug preventing outward pressure. On heating the tube thus prepared in the air-bath, the blue color disappeared before the critical point was reached, and the loss of color was accompanied by the deposit of a white powder. It was at first thought that this was due to the presence of water in the ammonia, but many experiments, in which every care was taken to have the ammonia perfectly dry, failed to give any other result. In one case only, when the temperature had been raised very rapidly, did the blue color remain above the critical point, and this only for a few seconds. This chemical action most probably consists in the formation of sodamide, and this view is supported by the fact that one of the tubes opened under mercury gave a quantity of gas not dissolved by water.

As the solution of an alkali metal seemed best adapted for spectroscopic examination, we made an attempt to dissolve sodium in compressed hydrogen. For this purpose a tube with a very large expansion was made, and filled with carefully dried hydrogen. While the stream of gas was still passing, a small piece of sodium was placed in a pocket at the end of the tube, and the aperture closed before the blow-pipe. In this experiment we used no manometer, our intention being to increase the pressure slowly and to make it as great as possible. After about half an hour, at a pressure, so far as we could judge, of about 300 atmospheres, the mercury, which had never come in contact with the solid sodium, was observed to become thick and pasty. At this point the tube burst (no further pressure had been put on) close to the iron cap, and, on examining the broken piece, small semi-solid globules of mercury were observed adhering to the glass, marking the highest point to which the mercury had reached. These were taken out and placed in water, when small bubbles of gas were observed rising from them. In another experiment a small rod of sodium, quite filling the capillary bore, was observed to be gradually corroded, until only a shell adhering to the glass remained. The very frequent bursting of the tubes, made more frail by the reduction of lead oxide, due to the action of hydrogen on the hot glass, makes the demonstration of the solubility of sodium in hydrogen exceedingly difficult, but the phenomena described, we are convinced, can only be explained on this hypothesis. In several experiments we have seen little pieces of sodium slowly disappear, leaving only the thin shell of oxide formed round them while they were being placed in the tube. There seemed in many cases to be a sudden chemical action, for the tube burst, not while pressure was being applied, but often several minutes after the pressure screw had been advanced. A beam of light passed through the tube showed no absorption when examined by the spectroscope.

Having described our experiments, it remains only for us to consider the state of the solvent at a distance above the critical point. We cannot do better than quote Dr. Andrews' consideration of the subject. He says:* "What is the condition of carbonic acid when it passes at temperatures above 21° C. from the gaseous state down to the volume of the liquid without giving evidence at any part of the process of liquefaction having occurred? Does it continue in the gaseous state, or does it liquefy, or have we to deal with a new condition of matter? If the experiment were made at 100° C., or at a higher temperature, when all indications of a fall had disappeared, the probable answer that would be given to this question is, that the gas preserves its gaseous condition during the compression, and few would hesitate to declare this statement to be true, if the pressures, as in Natterer's experiments, were applied to such gases as hydrogen or nitrogen. On the other hand, when the experiment is made with carbonic acid at temperatures a little above 31° C., the great fall which occurs at one period of the process would lead to the conjecture that liquefaction had actually taken place, although optical tests carefully applied failed at any time to discover the presence of a liquid in contact with a gas. But against this view it may be urged, with great force, that the fact of additional pressure being always required for a further diminution of volume, is opposed to the known laws which hold in the change of bodies from the gaseous to the liquid state. Besides, the higher the temperature at which the gas is compressed the less the fall becomes, and at last it disappears." Leaving out of consideration the solubility of sodium in hydrogen, we have had iodide of potassium in solution in alcohol at temperatures much too high for measurement by the mercurial thermometer, and which may safely be estimated at 150° C. above the critical point (=380° C.) We think, therefore, we are justified in saying that at this high temperature the solvent was truly gaseous. An examination of Dr. Andrews' curves for carbonic acid shows us that at a temperature only 16° C. above the critical point, the sudden fall in volume corresponding to the boiling line has disappeared, and although the curve does not coincide with the air curve, it is regular, and shows no sign of liquefaction having occurred. Our experiments were made at temperatures further removed from the critical point than this, and as no sudden change in solubility could be detected in passing from the liquid state to these high temperatures, we conclude that, in these experiments, we have further proof of the perfect continuity of the liquid and gaseous states, and also a complete proof of the solubility of solids in gases.

* "Phil. Trans.," 1869, p. 575.

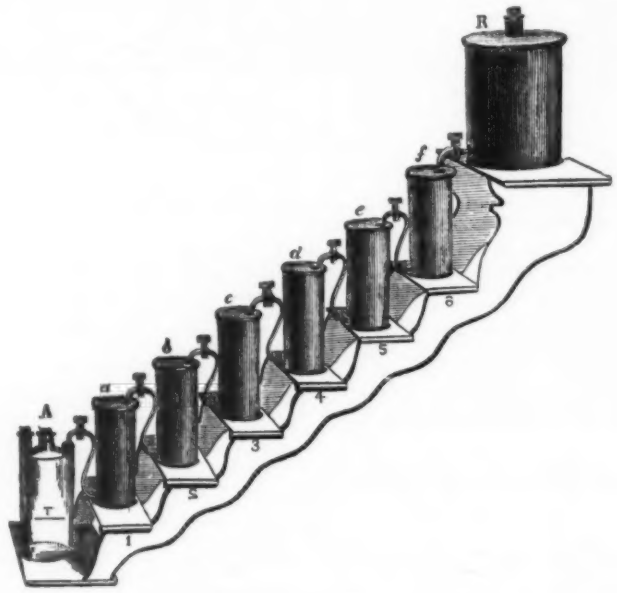
JULHE'S EXTRACTION APPARATUS.

WE illustrate a new extraction apparatus, which yields uniform and concentrated fluid extracts automatically. It is particularly useful for the preparation of fluid extract of cinchona: 1. That it completely exhausts the bark, so that the residue will yield nothing further either to water or to alcohol; 2. That it produces a solution of any desired degree of concentration without the aid of heat; 3. That it furnishes standard and concentrated solutions, independently of the richness of the bark employed.

The apparatus consists of six displacement vessels, arranged as shown in the cut, so that the liquid passing out of the upper vessel has to pass, successively, through the whole series, before it arrives at the receptacle, A. The menstruum is contained in the reservoir, R. The process is best explained by supposing the apparatus to have been in operation for some time, and to be so regulated that the receiver, A, becomes filled within 24 hours to the mark, T, corresponding, in the case of cinchona, to a weight of fluid extract equal to the weight of bark introduced into any one of the displacers. Whenever the mark, T, is reached by the fluid extract, all the faucets are closed, the receiver is emptied and replaced, the uppermost displacement vessel, *f*, is removed, emptied of the exhausted bark, charged with fresh bark, and then put on the lowest step of the ladder after all the other displacement vessels have been set one step higher.

The faucets are then opened again, that of reservoir, R, however, only far enough to deliver the menstruum in drops. The outer ascending tube of the vessels causes the liquid to thoroughly penetrate and macerate the bark, which would not be the case if the faucets were at the bottom.

At the end of six days, after six repetitions of the process,



JULHE'S EXTRACTION APPARATUS.

the displacement vessel, *f*, will have re-arrived on the sixth step; and supposing that at each station, during its progress, it loses one-half of the extractive matter, it will then contain only $\frac{1}{64}$ of the original soluble matter. The bark which is removed from the vessel, *f*, is not thrown away, but allowed to accumulate for a sufficient number of days, and then subjected to strong pressure, in order to remove the menstruum it still contains. This is poured into the reservoir, R. The relation of the extract to the bark is regulated on the following basis. 10 grammes of gray bark yield on average 2·1 grammes of hydro-alcoholic extract; and 10 grammes of yellow bark yield on an average 2·1 grammes of the same extract. Mr. Julhe prepares his fluid extract so that each kilogramme of the latter represents one kilogramme of the *normal* bark, yielding the before-mentioned percentages of dry extract. In the case of poorer barks, he proportionately diminishes the amount of the product, so as to obtain the same result. Hence, each time a new lot of bark is taken in operation, it is necessary to evaporate 10 grammes of the first lot of extract obtained, and to regulate the height of the mark, T, so that each 10 grammes will correspond to either 2·1 grammes or 2·7 grammes of dry extract, according to the nature of the bark. Mr. Julhe's price for fluid extract of gray bark is 15 francs, and for that of yellow bark 30 francs per kilogramme.

EXAMINATION OF MUSTARD.

By CHANNING T. GAGE, Ph. G.

SOME time last year my attention was called to the great difference in the various samples of mustard, whether purchased for food or for external use. At one place there was much complaint that the mustard from a certain store was practically worthless, there being very little strength to it. For this reason I commenced a microscopical examination of samples bought in different parts of the State; I used a power of 375 diameters, though all impurities can be detected with much lower powers.

Black mustard is of most frequent occurrence, though the white is occasionally mixed with it. The principal impurities found were wheat flour and oat starch, easily identified by the peculiar structure of the grain, also by treating with iodine, on the slide of the microscope, when the mustard becomes of a yellow color (before of a whitish cast), while the starch grains are changed to a deep blue, thus forming a striking contrast, by means of which the quantity of starch present can be more easily estimated; for pure mustard contains no starch.

Figure 1, ×375 diameters, contains illustrations of the structure as seen in fragments in commercial samples. A is outer thin mucilaginous layer of cells; B, the next coat below, dark brown with light brown cavities between, as seen in the cross section, C, forming a tough flexible coating. The next layer is usually seen attached to this brown coat as in D, and detached from its proper place as a layer of cells, surrounding the central part of the seed as in E, which is also very common. G shows the gray granular material contained in the center of the seed with its loose broken cells which are irregular and very thin. F, I, and H are varying forms of those already described.

Figure 2, ×375 diameters, contains impurities found in mustard. A is the yellow fibrous material containing the turmeric starch, the grains themselves seldom being seen. This is of a bright-yellow color, and is used to counteract the whitening caused by the large addition of wheat flour, C, and oat starch, B, the former being the more common. D is a fragment of wheat bran often seen. E is rye starch found in one sample. F is corn starch.

Figure 3, ×375 diameters, shows the appearance of one sample as seen in the field of the microscope and drawn with the camera lucida, representing as nearly as possible the average of the sample. Capsicum is occasionally seen, but in very small amounts, hardly noticeable.

Of ten samples examined, three contained a small amount of wheat, only a few grains in each field of the instrument as successive portions of the slide came into view; two contained a large proportion of wheat starch, oat starch, and were strongly colored with tumeric; the sixth contained wheat, bran, and tumeric; the seventh, wheat and rye; the eighth, corn and wheat; the ninth, oat; and the tenth, wheat starch: all of the latter in large amounts.

Some of these were claimed to be pure, other were not. Many dealers say they cannot sell pure mustard, it being so much more expensive than the mixture commonly sold. It is true that these are sold at much less than the pure article, but from what I have learned in the matter, the price is not generally reduced in proportion to the quantity of foreign material introduced. Indeed, this matter of weak mustard has become so common that there is a company that is manufacturing mustard plasters, ready to be moistened and applied. These I have examined, and found them to be microscopically pure, and also capable of "drawing" more than would four times the quantity of common mustard. It seems to me that any dealer who made it a point to keep nothing but pure drug, by proper management in buying and advertising, would be successful in establishing a business which would be beneficial both to him and his customers.—*New Remedies.*

FIG. 1. FIG. 2. FIG. 3.

ALCOHOLS IN UNFERMENTED FRUIT JUICES.

By Dr. GUTZEIT.

THE author extracted the unripe fruits of *Heracleum giganteum* with ether free from alcohol. In the watery stratum of the extract free ethylic and methylic alcohol was detected. In the ethereal stratum was found butyric-ethyl-ester along with solid hydrocarbons of the formula C_nH_{2n}.—*Jena Zeitschrift Naturw.*

MINERAL LUBRICATING OILS.

By Dr. OSCAR BREMKEN.

THE author determines: 1, the specific gravity; 2, the temperature at which inflammable and continuously combustible gases are evolved. For this purpose he heats the oil on the sand bath in a crucible, 6·4 c.m. wide and 4·7 in depth, filled to 1·2 c.m. from its edge, and after the experimental temperature has been attained, he removes it from the sand bath and passes a small gas flame over it, as in Hannemann's petroleum test, trying it first from 5 to 5 degrees and afterward from 2 to 2. Oils which foam strongly when heated are unfit for many purposes. He observes, further: 3, the point of congelation; 4, the undissolved constituents on dissolving 10 c.c, in an equal volume of ether, filtering and weighing the washed residue; 5, the reaction with soda lye of sp. gr. 1·40; 10 c.c. of the oil are well shaken up with 5 c.c. of the soda lye and heated in the boiling water bath. After repeated shaking the lye must remain clear, and its volumes must not be altered. The test tube used in this experiment must be absolutely free from grease; 6, the reaction with nitric acid of sp. gr. 1·45; on agitating equal volumes no rise of temperature, or but a very slight one, should be perceptible. This test shows the absence of tar oils; 7, reaction with sulphuric acid, sp. gr. 1·53; equal volumes are shaken up and heated in the water bath, when the acid should take merely a pale yellow color. A brown or black coloration shows imperfect refining, or, along with No. 6, the presence of tarry oils; 8, behavior on shaking with water; the water must remain clear, free from a whitish turbidity, and should not have an acid reaction.—*Zeitschrift Anal. Chemie.*

NITROGEN, SULPHUR, AND CHLORINE IN ORGANIC BODIES.

By Dr. P. SPICA.

INTO a small tube of about 5 mm. diameter is put a small quantity of the substance under examination along with a globule of sodium or potassium. It is heated strongly, and when the tube is red-hot the contents are thrown into a small beaker, containing a few grammes of pure water. The liquid is heated, filtered, and divided into three portions. If a drop placed upon a slip of polished silver produces a black spot, sulphur is present. Another portion of the liquid is treated with a mixture of ferric and ferrous salt, and then with a few drops of dilute hydrochloric acid, to dissolve the ferric hydrate. A blue coloration or precipitate indicates the presence of nitrogen. The remaining portion of the liquid is treated with dilute nitric acid, and then with silver nitrate, if the results of the former tests have been negative, in order to detect chlorine (bromine or iodine). If one or both of the former tests have given positive results, the liquid is heated for two minutes with its own volume of pure concentrated sulphuric acid, in order to decompose alkaline sulphide and cyanide, and silver nitrate is finally added.

SULPHURETED HYDROGEN IN BEER.

WE have lately drawn the attention of our readers to a change which often takes place in certain beers, resulting in the development of a most unpleasant odor. This change is most marked in the warmer months of the year, and has been specially noticed in those beers which have been brewed with waters containing a large proportion of sulphate of lime, such as are used at Burton-on-Trent and elsewhere. This objectionable odor was last year so conspicuous, that many brewers had large quantities of beer thrown back into their hands, and had great difficulty in disposing of it. Many theories have been propounded to account for this disastrous phenomenon; at one time it has been thought that fusel oil is the cause of the unpleasant smell; and at another it has been attributed to the production of certain ethereal oils during the second fermentation; we have, ourselves, pointed out that, under certain circumstances, butyric and valerianic acids may be formed in beer, the last-named acid being formed from the hops; these acids possess very powerful odors, but still very different to that which is the characteristic of the beers we are referring to; these "stinking" beers remind one of sulphureted hydrogen, and we have before pointed out how this objectionable constituent may be produced from sulphates by the action of putrescent organic matter. Some recent researches of M. Miquel, however, throw a new light on this question; he has observed that proteic matters, such as albumen, fibrin, etc., are decomposed by certain minute organisms of the genus vibrio, or bacillus; he has more particularly detected a variety of these microscopic creatures in sewage water, drinking water, and even in some instances in rain water, and he has further observed that these organisms attack albumen and decompose it, converting all the sulphur, which is a normal constituent of this substance, into sulphureted hydrogen. Miquel also experimented on vulcanized caoutchouc, and found that the same organism would also convert its sulphur into sulphureted hydrogen. This organism, which is very minute, is what Pasteur defined as anerobic, that is, it lives and multiplies in a fluid totally deprived of air. When this organism was placed in contact with albumen, caoutchouc, or other substance containing sulphur, in the presence of alkalies, Miquel found that the corresponding sulphides were produced, and in this way very appreciable quantities of sulphides have been obtained. We have here a clew to the cause of the unpleasant smell observed in certain beers; no doubt in some way or other the beer, whilst in process of manufacture or during storage, becomes impregnated with the organisms detected by Miquel, and then, under suitable conditions, especially of temperature, the albuminous constituents, and, in fact, any bodies containing sulphur, gradually begin to yield sulphureted hydrogen and, a very minute quantity of this gas is sufficient to impart an unpleasant flavor to a large bulk of beer. At present the organism, or organisms, which produce this serious result have not been described with sufficient exactness to enable us to detect their presence in beer, but as our knowledge progresses, we shall, no doubt, in time be able to identify and counteract their injurious effects.

ACTION OF OZONE ON CERTAIN NOBLE METALS.

By Prof. A. VOLTA.

SILVER quickly becomes covered with a layer of black oxide. Gold is perfectly unaffected by ozone, whether moist or dry. Platinum gave the same results as gold. Palladium, if perfectly freed from hydrogen, is polarized negatively in ozone, like the other noble metals, and even in a moist atmosphere it does not decompose ozone. Mercury is superficially oxidized by ozone, whether moist or dry.—*Gazzetta Chimica Italiana.*

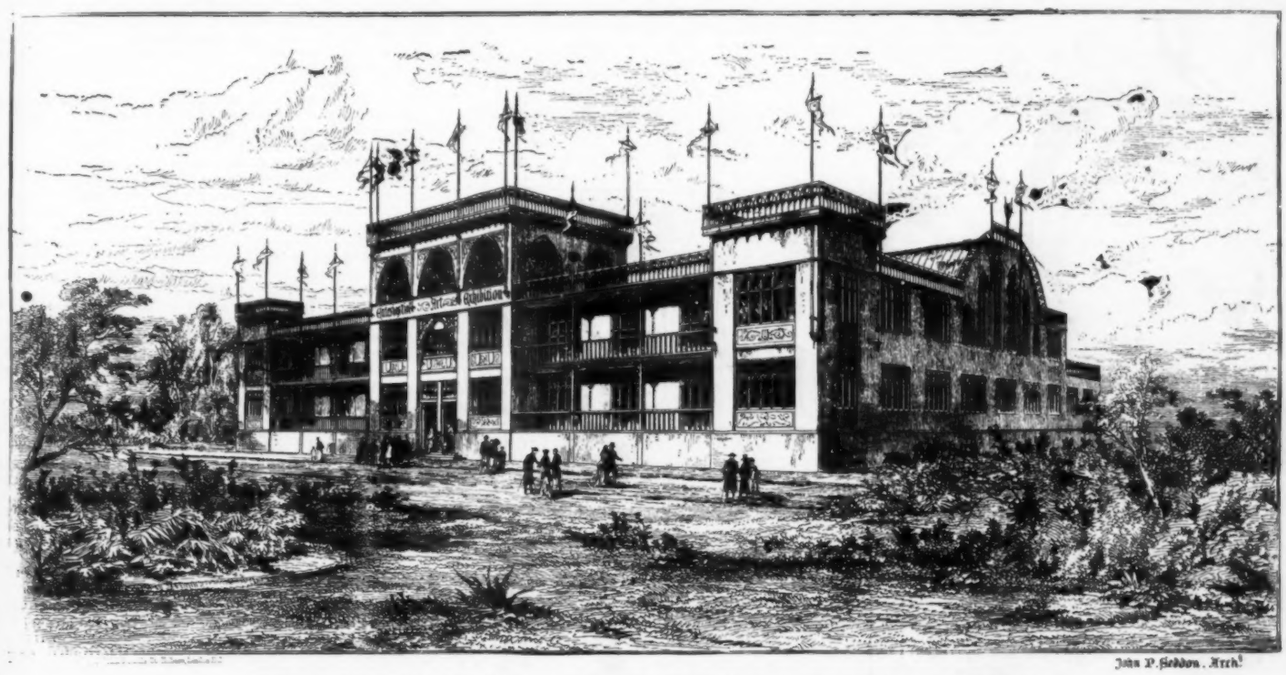
PREPARATIONS OF CRYSTALS FOR THE POLARISCOPE.

AFTER preparing crystals, dry, in Canada balsam, and in castor oil, it occurred to me to attempt to preserve them in their own mother liquor. To do this paint on a slide a thin ring of gold size, whose entire diameter shall equal that of the cover glass. To make the edges of the ring smooth and true hold the flat edge of a small chisel against them while whirling the turn-table. As soon as the ring is finished heat it over the flame of a lamp until it becomes brown. Put into a test tube a little salycine, tartaric acid, prussiate of potash, or other substance adapted for examination with the polariscope; add water and apply heat until the solution is of such strength that crystals will form in it only when quite cold. Coat the ring, already hardened, with a little fresh size, and likewise the edge of the cover glass. Put the slide and cover glass thus prepared on the hot plate for a few minutes, and then pour a few drops of the boiling solution from the test tube into the cell, and apply the cover glass immediately, pressing it down gently with a dry cloth which will absorb the superfluous liquid. Touch the edge of the cover glass with gold size, and then transfer to the turn-table and finish. If the above directions have been followed correctly, the cell will contain a clear liquid which begins to deposit crystals as it cools. Transfer the slide to the stage of the microscope soon enough to watch this process. Without the aid of the polariscope it is of interest, but with that accessory the spectacle presented is exceedingly beautiful.

After standing for some time, however, the crystals appear to lose their sharpness and perfection of form. They may be restored by a fresh application of heat sufficient to cause them to dissolve and enter upon new forms of combination. As a means of observing the process of crystallization this method appears to be the best, and many of the results as respects brilliancy of color and perfection of outline are unsurpassed. I would recommend, however, that those who have not tried it should make a moderately strong solution of salycine or tartaric acid in boiling water and pour it over a warmed slide, draining off the greater part immediately. When crystallization ceases put a drop of Canada balsam in the center of the slide and apply a cover glass. Examine and, if found satisfactory, harden the balsam and finish in the usual way. Having once learned these processes, there is no limit to the range of experiments that may be made. For instance, a strong solution of santonine in chloroform gives very fine crystals, which are quite permanent and brilliant when mounted dry. It should be noted that the quantity and strength of the solution employed will modify the results obtained, also agitation of the fluid whilst evaporating will in some instances introduce crystals of an entirely different form from those obtained when it is permitted to remain undisturbed.—*M. A. Verder.**

THE ECCLESIASTICAL ART EXHIBITION.

THE view of the proposed Ecclesiastical Art Exhibition, which we publish this week, represents the building designed for the purpose by John P. Seddon, architect, of No. 1 Queen Anne's Gate, Westminster. The site chosen for it is unquestionably a superb one. It is that known as the Savoy site upon the Victoria Embankment, overlooking the gardens which extend from Charing Cross to Waterloo Bridge, a little lower down the river than the Cleopatra's Needle. It will have approaches from the Strand and Savoy, as well as from the Embankment, and so is readily accessible from all parts. The building is indeed intended as a temporary one, and yet will be constructed in a durable and fireproof manner, in accordance with the requirements of the Board of Works. It will comprise a vast central hall 180 ft. long by 50 ft. wide, and about 50 ft. high, with annexes on either side, and toward the Embankment there will be a range of saloons and refreshment rooms commanding unrivaled views of the river and its embankment. The construction is intended to be mainly of iron, with enrichments of mosaic. It will be especially arranged to accommodate stained and painted glass in windows of appropriate character, which can be modified as may be desired by the various exhibitors in that department of ecclesiastical art. A prominent place will be given for a fine organ, with a music chamber in its immediate proximity. Artists and art manufacturers in England and abroad are earnestly solicited to avail themselves of the unique opportunity afforded by this exhibition building to display their best workmanship. The advantages of such a building in so rich a position in the metropolis are so obvious as not to need further comment, and the utmost exertions on the part of those who are interested in the class of artistic productions for which this important structure has been designed are confidently relied upon by the committee who have promoted the undertaking. Further information can be obtained by applying to Mr. John P. Seddon, architect and vice-chairman of the committee, or of Mr. John Bray, the secretary, 267 Strand, W. C., London.—*Building News.*



John P. Seddon, Archt.

THE ECCLESIASTICAL ART EXHIBITION BUILDING, LONDON.

THE SCIENCE OF GAS BURNING.

MAJOR SHARRATT lately gave an interesting lecture in the Old Town Hall, Manchester, on "The Science of Gas Burning, with Useful Suggestions." He called attention to the prevailing ignorance of the public generally as to the science of gas burning, and consequently the great injury to personal comfort and health as well as the heavy pecuniary loss resulting therefrom. Of all the gas that actually passes through the meters and was paid for, from 30 to 50 per cent. was wasted from imperfect combustion and other causes, and so was injurious to the health and property of the purchasers. In Salford alone the direct loss so incurred was £30,000 per annum, in London it was £500,000, and in the entire country it was estimated at nearly £3,000,000 per annum. The chief causes of this waste of public money were (1) bad burners, (2) excessive pressure, (3) unsuitable arrangements of gas globes and fitting. To insure the best results with the greatest economy it was essential to burn gas under

* *American Naturalist.*

low or very moderate pressure, and to effect this gas engineers and others had recently made great improvements in the construction of burners and regulators. The illuminating power of gas was better in Scotland than in England, owing to the superiority of the coal used in its manufacture. The price of gas varied considerably sometimes with the quality, frequently from other causes. In Leeds 18-candle gas was charged 2s. 2d. per 1,000 cubic feet, in Edinburgh 28-candle gas was 4s. 2d., in London 15-candle gas was 3s. 4d., in Salford 20-candle gas was 3s. 4d. The lowest quality of gas made was equal to 14 candles, and the average price throughout the country was 4s. per 1,000 ft. The lecturer noticed the great improvement in street lighting, as illustrated by the new Argand lamp at the bottom of Market street, and the effective Bray lamps, with compound lights, used in Piccadilly. The use of gas regulators to be attached to meters, checking excessive pressure, and so preventing "blowing" and other waste of gas, was explained and illustrated by Messrs. Stott & Co.'s improved regulator, which, being constructed entirely of metal and glass, was found to be the most durable and constant in action, effecting, as the makers report, a saving of 30 to 50 per cent. in the consumption of gas used in mills, public buildings, and houses. The relative merits of wet and dry meters, as well as the peculiarities of their construction, were also explained by Major Sharratt, and the great importance to gas consumers of taking weekly records of the index of the meter was strongly advised to prevent errors and extravagance.

PROPORTIONS AND CONFORMATIONS OF THE HORSE.

WE present an engraving from the *Horseshoer and Hardware Journal*, showing the outline of a perfect horse, giving name of part, proportions, and familiar terms:

TERMS GENERALLY MADE USE OF TO DENOTE THE PARTS OF A HORSE.

1. the vertebræ of the neck.
2. The sternum, or breast.
3. The scapula, or shoulder-blade.
4. The humerus, or bone of the arms.
5. The radius.
6. The ulna.
7. That part of it called the olecranon, or elbow.

i. Foot.
ii. The coronet.
k. Body.
l. Quarters—over the hips is called the croup.
m. The dock.
n. The sheath.
o. Hock—where curbs come.
p. Shank-bone.
q. Fetlock-joint.
r. Pastern.
s. Foot.
t. Thigh.

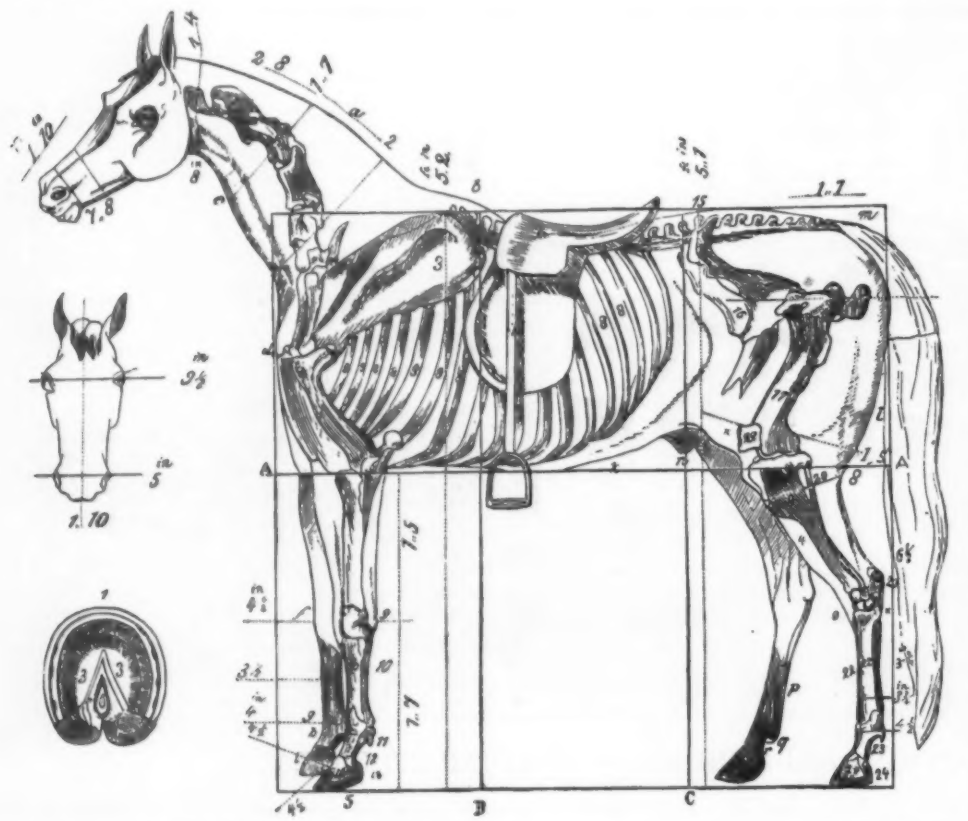
THE FOOT.

1. The toes of the foot.
2. The horn of the foot.
3. The sole.
4. The frog.
5. The heels.

THE PROPORTIONS OF A HORSE.

AA. The line which divides the body from the legs, giving the proportion of both.
BC. The line which divides the body from the fore and hind quarters, giving their respective proportions.

	Ft.	In.
The length of a head generally	1	10
Across the eyes	0	9½
Across the nose	0	7
From the eye to the cheek-bone	0	8
The neck across the gullet	1	4
The middle of the neck	1	7
The junction of the neck to the body	2	0
From the withers to the ground or base line	5	2
From the rump, or highest part of the loins to the ground	5	1
From the elbow to the stifle	2	4
From the elbow to the knee	1	5
From the knee to the ground	1	7
From the withers to the chest, being the depth of that part of the body	2	3
Across the arm	0	6
Across the knee	0	4½
Across the shank-bone under the knee	0	3¼
Across the fetlock-joint	0	4



LA PORTE'S PROPORTIONS AND BONE STRUCTURE OF THE HORSE.

8. The ribs; eight of which are called superior ribs, connected with the sternum; the others are called the false ribs.
9. The bones of the carpus.
10. The metacarpal bone.
11. The great pastern.
12. The little pastern, or coronary-bone.
13. The coffin-bone.
14. Vertebræ of the back.
15. The six vertebræ of the loins—there are eighteen bones in the tail.
16. The os innominatum, or basin-bone.
17. The femur, or thigh-bone.
18. The patella.
19. The tibia, or greater bone of the leg.
20. The fibula, or small bone of the leg.
21. The bones in the hock.
22. The metatarsal bone.
23. The great pastern and the lesser pasterns.
24. The coffin-bone.

FAMILIAR TERMS.

a. The crest. When horses are out of condition this part wastes, and they are said to be crest-fallen.
b. Withers.
c. Throat.
d. Shoulder-points.
e. Arm.
f. Knee.
g. Fetlock-joint.
h. The pastern-joint.

Across the pastern	0	3
Across the coronary-bone	0	4½
The highest part of the hoof	0	4½
The length of the hoof, *i. e.*, from toe to heel	0	5¼
From the rump to the tail	1	1
From the hip to the end of the quarters	1	9
Across the hock	0	6½
Across the shank, below the hock	0	3¾
Across the fetlock	0	4½

FERTILIZATION OF FLOWERS BY HUMMING BIRDS.*

FOR several years some persons of this place have been watching the birds about flowers. They visit flowers for at least two objects, for insects and for nectar, and perhaps for pollen in some cases. Pollen grains have been found on the bill and feathers of the head of humming birds. These birds have been seen to frequeut flowers of pelargoniums, fuchsias, trumpet-creepers, phloxes, verbenas, catmint, milkweed, tropæolums, honeysuckles, lilacs, morning-glories, cherry, wild balsams. I have no doubt they visit a great variety of other flowers which secrete honey in abundance. Mr. Osband visited trumpet-creepers, in flower, on bright days, and always saw birds. On one plant he saw eight birds at one time.

The pollen of fuchsias is sticky or in strings. Humming birds are the main visitors to the flowers. The calyx tube seems too long and narrow for most insects. Mr. Hollingsworth is very sure these birds visit the plant for nectar. Sometimes they pierce through the base of the calyx tube and take out the nectar. The student last named covered some flowers and found the stigmas were dusted with pollen without the aid of bees or birds. The ovaries also swelled as though forming seeds.

Mr. Wm. Snyder observed the fertilization of *Impatiens fulva*. The anthers form a covering over the pistil. He tied bags over young flower buds, also over flowers which had opened but before the stamens had disappeared. In both cases no good seeds were produced. Some he tied up and artificially crossed. The latter, without exception, matured fruit. In other cases he cut off all the petals of the flowers. He took down the signs. None of these set fruit. In other cases the nectar gland only was removed, with no fruit setting.

Sometimes he saw a large number of black bees at work, seemingly trying to get what exercise and nectar they could. They ran in and out many times, and hardly ever touched an anther or pistil. He could not see that the insects were of any use in fertilizing the flowers. Small wild bees behaved no better as far as carrying pollen was concerned. A common honey bee availed nothing in this direction. One humble bee hit pollen in his plunges to get at the nectar, but left the plant after trying a single flower. In frequent visits he often saw humming birds about the flowers going to all that were open at the time. Every time the birds thrust their beaks into the flowers, if the stamens had not yet been removed, the head, a little above the beak, would hit these and become dusted with pollen. Where the anthers had been removed the bird's head left pollen on the stigmas. He saw, in one cluster, all the flowers visited twice in fifteen minutes. He is confident that *Impatiens fulva* is cross-fertilized mainly, if not wholly, by humming birds.

* Notes taken from papers of his young students by *Prof.* W. J. Beal. —*American Naturalist.*

Reagent for Lime.—This is sodium tungstate, as proposed by Sonstadt. As calcium tungstate is somewhat soluble in sodium tungstate, it is necessary where very small quantities of lime are present, *e. g.*, in the analysis of water, to add the reagent drop by drop.

ADAPTATION OF CICINDELIDÆ.

IN looking over the family of Cicindelidæ in a speculatory way, I drew the inference that the line of descent diverged (probably in the mesozoic age) into branches, the lowest* and certainly the oldest of which is still represented in the genus Amblychila. In Omus, Tetracha, *Cicindela pilatei, C. maga, C. cursitans,* and *C. celeripes* we have an aberrant lesser branch, the latter genera being closely linked with the rest of the Cicindelidæ.

Contemplating the law of adaptation and heredity, I arrived at the conclusion that the prototype of Amblychila formerly lived on the shores of the great intercontinental gulf in cretaceous times, before the arrival of *Cicindela hirticollis,* and *C. lepida,*† and was in those ages provided with a more specialized structure, which by degrees became retrograded and inherited when its survivors adapted themselves to the clay-banks of the undulating prairies of Colorado and Kansas. It probably formerly led a life, like its congenors in Mexico and South America, on leaves of trees, along the shores of the great gulf; the consequent breaking up of the latter into innumerable salt and brackish lakes being the primary cause of its retrogradation.‡

Owing to the light membranous body of insects, they were less likely to be destroyed§ in prehistoric evolutions than were vertebrates and many invertebrates; consequently future researches in the rich deposits of the Rocky Mountain tertiaries may yet reveal the fossil ancestor of Amblychila.

As a secondary adaptation, I mention the pubescence of the middle tibia in the male of Megacephalini and Cicindela (excepting in *C. pilatei* and *C. maga*, where it is glabrous). It is intended for a firmer hold of the female during copulation; in Amblychila the dilatation of the anterior tarsi in the male was dropped as useless, probably owing to the smooth cylindrical thorax of the female, and was replaced by an acute hind trochanter‖ for firmer insertion into the funnel-shaped pores between the ridges of the elytra of the female. This structure was useless to the female, and therefore the trochanter remained blunt. We find similar inherited adaptations in the serrulate and curved middle tibia of *Calosoma sayi*;¶ the dilatation of the anterior tarsi was in this instance preserved. Although *C. sayi* occurs frequently in Kansas and thereabouts, its frequency is probably checked by some enemy; its large size, and perhaps other causes, lessen its number. The interrupted elevations between the longitudinal ridges of its elytra are also, perhaps, fit for the acute trochanter of the male.

Whenever we find characters dropped because they are of no apparent use, we find them existing elsewhere, where they are probably also useless. They are merely—as are, for instance, the arthropodous trochanters—rudimentary organs which become important indications in comparative anatomy for tracing their ancestral connections, at the same time teaching, also, how an organ is apparently preserved without purpose for an indefinite time. In order to understand the teleology of certain inherited organizations it is necessary to be perfectly acquainted with the external conditions and the biology of the respective species. Adapted forms and accommodations are explicable only upon such conditions. Since the determining impulses for transitions and changes in organisms lie outside of the latter, or are to be sought there for the greater part, they thus often escape our observation.

Instances could also be mentioned of sexual peculiarities which seem to be in opposition to easy copulation, yet the species are abundant. Such apparently conflicting facts could undoubtedly be explained if we had full knowledge of the peculiar biology of those species. Amateur entomologists ought, therefore, by accurate biological observations, to concentrate their studies especially upon this generally neglected theme.—*Carl F. Gissler in Psyche.*

* Deficient in organ of sight, less specialized in organs of reproduction and in larva, reduced in abdominal segments, and wanting wings.

† Le Conte: Address of Retiring President (Proc. Amer. Ass Adv. Sci., 1875 [v. 24], p. 1-18), p. 4. Horn: "Notes on some Coleopterous Remains from the Bone Cave at Port Kennedy, Penna." (Trans. Amer. Entom. Soc., 1876, v. 5, p. 241-244) ("Misc. papers on Amer. Coleoptera," p. 241-245), p. 241.

‡ Le Conte: "Classification of the Coleoptera of North America," p. 1.

§ Le Conte: Address (*l. c.*), p. 8. "Cataclysms and submergences, which would annihilate the higher animals, would only float the temporarily asphyxiated insect, or the tree trunks containing the larvæ and pupæ, to other neighboring lands."

‖ Horn: "Sexual Characters of North American Cicindelidæ." (Trans. Amer. Entom. Soc., 1875, v. 5, p. 232-240, pl. 1 in part) (Misc. papers on Amer. Coleoptera, p. 232-240, pl. 1 in part), pl. 1, fig. 18.

¶ Horn: *ibid.*, pl. 1, fig. 26.

THE FOSSIL LOVERS.

MISS ANN GELICA kindly sends us her reply to Bret Harte's Geological Madrigal, which she assures us is addressed to her. To enable the reader to understand the young lady's reply we prefix "Dear Bret's" verses:

A GEOLOGICAL MADRIGAL.

(After Shenstone.)

I have found out a gift for my fair,
I know where the fossils abound,
Where the footprints of *Æsa* declare
The birds that once walked on the ground;
O, come, and—in technical speech—
We'll walk this Devonian shore,
Or on some Silurian beach
We'll wander, my love, evermore.

I will show thee the sinuous track
By the slow moving Annelid made,
Or the Trilobite that, farther back,
In the old Potsdam sandstone was laid.
Thou shalt see, in his Jurassic tomb,
The Plesiosaurus embalmed;
In his Oolitic prime and his bloom,
Iguanodon safe and unharmed!

You wished—I remember it well,
And I loved you the more for that wish—
For a perfect Cystistidian shell
And a *whole* Holocephalic fish.
And O, if earth's strata contains
In its lowest Silurian drift,
Or Palæozoic remains
The same—'tis your lover's free gift!

Then come, love, and never say nay,
But calm all your maidenly fears,
We'll note, love, in one summer's day,
The record of millions of years;
And though the Darwinian plan
Your sensitive feelings may shock,
We'll find the beginning of man—
Our fossil ancestors in rock.

My Reply to Dear Bret's Madrigal.

Thy epistle, dear Bret, I've received,
And trust thou'lt not think me too bold,
If I frankly acknowledge I'm grieved
At the thought that to thee I've been cold.

How sweetly thou managest wooing!
What a way to my heart thou hast found!!
Abandoning billing and cooing,
Thou tell'st me where fossils abound.

For ever henceforward I'm thine,
To view Ornithichnites I'm sighing;
(Don't delay—for a ramble I pine),
To find them *in situ* am dying.

Tridactylous, struthious, and huge;
With phalanges nicely indented,
Entombed when Dame Nature with rouge
The marl and the sandstone beds painted.

If thou wilt but extract me a femur,
With matrix just near the trochanter,
I'll abandon all maidenly tremor,
And at once name the day, thou enchanter.

I'll only make one stipulation—
That, avoiding hotel, inn, and tavern,
We improve the time honored lunation,
And our honeymoon spend in a cavern.

There I'll labor, content in the fetter,
To find, happy thought! if I can,
A dear second husband and better,
A petrified pithecoid man. —A. G., *in Nature.*

ART AND NATURE.

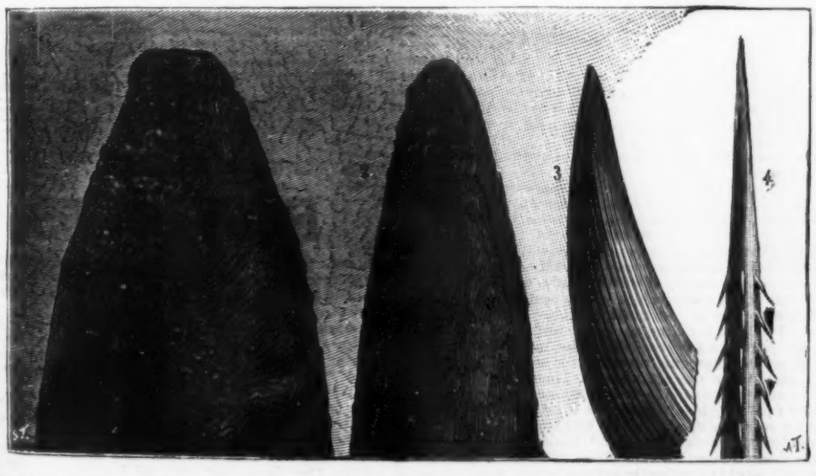
IN making a microscopical preparation, one day, I made use of one of the steel points usually employed for such purposes, and as I had occasion to place it under the microscope I was surprised to see how rough and coarse an appearance it exhibited when highly magnified. This observation gave me the idea of searching for some object with a finer point, and I was thus led to make a comparison of the different objects of which I herewith give a very correct representation. They will serve to show how coarse the handwork of man is when compared with the work of nature. Number 1 of the accompanying engraving shows the point of a pin which has been used, magnified 500 diameters. It will be seen that the point is considerably blunted or flattened. The malleable metal gradually gives way under the pressure necessary to cause it to penetrate tissues. No. 2 is slightly more pointed, and is an ordinary steel needle; still, it will be seen that it is very defective when examined with the microscope. But how sharp, on the contrary, is the spine of the rose, and what an extraordinary delicacy the sting of the wasp presents when examined under the same power of the microscope (Figs. 3 and 4). The very exact drawing given herewith has permitted me to make a calculation which leads to results that are quite curious. At half a millimeter from the point the diameters of the four objects represented are respectively, in thousandths of a millimeter, 3·4, 2·2, 1·1, and 0·38. The corresponding sections, in millionths of a square millimeter, are 907·92, 380·13, 95·03, and 11.34, or, in round numbers, 908, 380, 95, and 11. If we suppose, what is much under the truth, that the pressure that must be exercised on the point should be proportional to the section, admitting a pressure of 11 *centigrammes* as sufficient to cause the sting of a wasp to penetrate to a depth of half a millimeter, it would take a pressure of 9 *grammes* to make a pin penetrate the same distance. In reality the last-named figure is too small, for we have not taken into account the advantage possessed by both the sting of the wasp and the spine of the rose in their more elongated form, and which is much more favorable for penetration than the obtuse form of the pin. It would be easy to considerably extend observations of this sort to a large number of other objects, and the remarks which I have made on natural and artificial points might, for instance, be applied to tissues. No doubt a thread from a spider's web would leave far behind it a thread from the finest lace, and art would always find itself much distanced by nature.—*Dr. Z., in La Nature.*

A RAMBLE THROUGH CEYLON.

CEYLON, November 22.

SINCE my last from Egypt we have experienced some heat in the Red Sea and Indian Ocean, which has prepared us a little for the temperature of this island—at the present cold season about 85° in the shade. With regard to *The Ironmonger* I have only satisfactory information to impart. It is universally read, and highly appreciated by every one who deals in metals and hardware goods here. Those who deal in the finer class of these articles are very few, because it is only the Europeans who purchase. Of course, fireirons are out of the question when there are no fireplaces, and knives and forks are equally *de trop* for people who eat with their fingers, as nearly all the natives do; but the few storekeepers who do exist do business on a large scale, and deal in a great variety of goods. By far the handsomest store between Europe and Ceylon is that of J. Walker & Co., at Kandy. This store would be a credit to Oxford street both as regards the building and the selection and arrangement of stock. The firm certainly carry off the palm in this island for energy and ability. They also possess a large engineering business at Kandy, with branches up country for the convenience of the coffee planters. The supply of these same planters constitutes the bulk of their business, and they have succeeded in bringing to such perfection their coffee machines as not only to supplant those made at home, but the firm are also doing a large and increasing foreign trade. Of course, the fact of their being on the spot enables them to know exactly the requirements of the buyers, but on the other hand, having to compete with old-established shops, to import their materials and tools, and to educate the Cingalese and Tamil natives to a work so contrary to their habits and instincts, constitutes no mean task. The greatest credit is due to the Messrs. Walker for having brought this work to such perfection. In going over their factory I was much struck with a road tracer, of which they make large quantities, and which seems admirably adapted for the rough work generally required out here. This instrument combines great simplicity with economy of cost, the price being about 50s., as against a theodolite costing about £25 or Dumpy level from £6 to £8. Of course it is not claimed that it does all the work of these instruments, but it answers for the small requirements of this island, and can be used by the planter himself or even the cooly laborer. It consists of a triangle hung by its apex on a pin fastened to an upright staff, the bar of the triangle being a tube with a sight-hole at one end and a fine cross-bar at the other. Beneath the triangle, on a bar, is hung a weight, which can be moved either way so as to alter the center of gravity of the triangle. The side of the tube contains a graduated scale, and according to the distance which the weight is moved from the center the slope can be altered either upward or downward from level to an angle of 1 in 6. The triangle is fixed on the pole at a convenient height for the operator to look through, and there is a cross-staff of the same height, from which he looks at the distant point. This firm employ near 400 hands, and at their stores do a large trade in scales and locks, which are procured principally from Fairbanks and the Yale Company, U. S. They have also commenced importing electroplate from Simpson, Hall, Miller & Co., of New York, and saws from Disston, of Philadelphia.

The railroad from Colombo, the capital of this island, to Kandy, is very interesting and picturesque. We had exceptional means of seeing the country it traversed, through the kindness of Mr. A. E. Brown, assistant locomotive superintendent, who kindly permitted us to ride on the engine through the steepest part, including the pass of "Sensation Rock," where the road is cut out of solid rock, over a descent, quite perpendicular, of 1,100 ft. This railroad—government property—is remarkably profitable, although costly to make. It is largely used by the planters, and still more so by the natives, who are fond of traveling, but are otherwise not remarkable for enterprise. It also conveys large freights of rice and manure, the former to feed the coolies, the latter to feed the land, and brings down immense quantities of coffee. Coffee and cocoanut oils are the staples of the place.



VARIOUS POINTED OBJECTS AS SEEN UNDER THE MICROSCOPE MAGNIFIED 500 DIAMETERS.

1. Common Pin. 2. Sewing Needle. 3. Thorn of Rose. 4. Sting of Wasp.

THE WATER SHEDS OF THE STATE OF NEW YORK.

THE State of New York presents two of the most remarkable water-sheds on the North American continent, if not on the face of the globe. Though situated so near one another that their extremities may be said to almost interlock, they are widely different in their physical features and distribution of water supply. One has been made the mighty servant of man and is harnessed for his bidding, while the other bids defiance, gushing forth its waters at its will, sometimes flooding a vast area of territory, and again leaving its riverbeds to dry in the sun.

The most powerful of these is drained by the Oswego river. Its area contains no less than seven thousand square miles of territory. It comprises the well-known chain of lakes, some of which are of considerable size and importance —the Oneida, Cayuga, Seneca, etc., amounting to over four hundred square miles of lake surface. Besides being in themselves natural reservoirs, the State has further improved Seneca Lake so as to regulate the periodical flow of the water. The average flow of the water is thus secured at about 600,000 cubic feet per minute. Twenty miles above the mouth of the Oswego river is Three River Point. From this place, down stream, there is a fall of water amounting to seventy-five feet. This space is taken up by seven dams erected and maintained by the State. Of these, two are situated at Oswego, covering a fall of forty feet. These dams accord hydraulic privileges equal to 25,000 horse power. But a moderate outlay is required to keep the flow in the river near the average for the year. 75,000 cubic feet of this water supply are in actual use in Oswego, where a canal is provided for the reception which furnishes fifty runs of first class water and over seventeen of the second class.

Two dams are situated at Fulton with 20,000 horse power. At this point the water privileges are easiest available, although Oswego has the greater representation of industries.

The Oswego River water-shed produces clear cold water, which is perfectly under control of man, no matter what the circumstances or exigencies. The river bank forms a line teeming with industries, with millions of dollars of money invested. This water supply never endangers the lives of citizens or encroaches on their property, but on the contrary affords a roadway for inland navigation through the canals which it feeds.

Not so the other subject of this paper. Situated on the highest point in New York, among the Adirondacks, it submits to no governmental check, but ejects its turbid waters, dashing down athwart and over precipices, which in spring time bear before them bridges and valuable property, not to say the lives of mankind.

This water-shed covers an area of 2,000 square miles. It comprises not less than five hundred little lakes and lakelets, some of which are said to be as large as Cayuga. 4,326 feet above the sea level a little lake known as "Tear of the Clouds" starts the Hudson marching onward to the sea.

Here also rise the Moose, Beaver, Oswegatchie, Gross, Raquette, St. Regis, Salmon, Au Sable, Bouquet rivers and many other streams. Could the streams have a uniform flow during the year, the volume of water emitted would be enormous for economic use. But though violent in time of flood they are quite low, not to say often nearly dry, in summer time.

Strange as it may seem, these rivers are scarcely of use as bearing rich deposits for the low land, like the Mississippi, Missouri, etc. The region from whence they emanate is peculiarly hostile to cultivation, and has resented all attempts at settlement and immigration, and gives no return for the careful sewing of seed.

The waters afford few privileges of navigation to the hewer of timber or the excavator of ores in the mountains. They form, however, the fishing ground of America, and yield an abundance of the finny tribe. Its mission in futurity is now foretold as the solving of the problem of water supply to fifty millions of people who may possibly inhabit the Mohawk valley. For the present it is to gratify the pleasurable longings of mankind. The Empire State has, therefore, two grand water-sheds, the one for the accumulation of untold wealth and the other for its dissipation. But what is an empire without unlimited resources?—*W. H. Ballou.**

FARMING IN SOUTHWESTERN MINNESOTA.

ONE hundred and sixty miles southwest of St. Paul, writes a special correspondent of the London *Times*, in the midst of a capital game country, is Heron Lake Junction, whence the Black Hills branch of the St. Paul and Sioux City Railway is carried thirty-three miles to Woodstock, and is thence to pass through the Indian pipestone country, where easily-cut and readily-polished ferruginous and calcareous clay beds occur, visited once a year by the Indians, who believe the soil to be colored with the blood of their forefathers, and who reverently carry off supplies of the pipestone to be carved into various ornaments. Down this line will by and by be brought a portion of the varied mineral wealth of the Black Hills and the cattle reared in increasing numbers on the bluffs and valleys of the Dakota River. Five miles west of Heron Lake Junction, where the sportsman will find a capital hotel, the town of Dundee is rising; and three miles south, on the Southern Minnesota

* I acknowledge the valuable assistance of Mr. Charles Rhodes, a noted lawyer of Oswego, and Prof. Calvin, of the State Survey, in the preparation of this article.—*American Naturalist.*

Railway, is Airlie, where Lord Airlie, I am informed, has property and has contributed handsomely toward town improvements. Throughout these Western States lands are frequently pointed out belonging to Englishmen, who, to counterbalance the depreciation unfortunately going on in land property in England, are investing in desirable estates in America which are destined to advance in value as railways and emigration spread westward. A quarter of a century ago settlers from the older States and from Europe were buying farms in Illinois and Ohio at from $5 to $10 an acre. Although contemptuously said to be "played out," and not always producing as much wheat as they did when first brought under cultivation, these lands, nevertheless are selling at from $25 to $40 an acre, and some of the sellers are reinvesting in Minnesota, Dakota, Iowa, Missouri, or Kansas, confidently anticipating good interest on their investment and labor, and a similar steady increment in the value of their property. Of such promising investments there is an abundance throughout these Western States. In the State of Minnesota alone on the 1st of January, 1879, the official records report upward of ten million acres, unsurveyed and unoccupied, belonging to the United States. Three million acres of surveyed lands belong to the States, and about the same quantity is owned by the State of Minnesota. For these the appraised price is $2½ per acre for lands situated within railway limits and $1¼ for those without the twenty-mile limits. A considerable proportion of the most desirable of these State lands has already been taken up under pre-emption, homestead, or timber acts. Nearly seven million acres are still in the hands of the five competing railway companies who have conveniently "gridironed" the State of Minnesota with iron roads. For ten, and occasionally for twenty miles on each side of their lines, they have received each alternate section of a square mile, and these sections they are disposing of at prices varying, according to eligibility, from $3 to $10. Credit may be taken for payment, which may usually be made at the rate of $1 or $3 per annum, 7 per cent. being charged on the deferred payments.

Some idea may be obtained of the undeveloped food resources of America when it is thus recorded that in this one State alone there are twenty-three million acres of unoccupied lands, while in several other States and Territories an equal or greater extent of unclaimed lands is to be met with. Here in Minnesota is an ownerless, unoccupied tract two-thirds the extent of England. Supposing one-fourth of this area were in wheat and produced only thirteen bushels per acre—the average yield of the State during the last two unsatisfactory years of drought—there might here alone be grown seventy-four million bushels of wheat, or rather more than half the wheat exports of the United States!

Close to the railway, ten miles beyond Dundee, on a pleasantly rolling prairie, by a pretty lake side, the zealous Roman Catholic Bishop Ireland is planting the township of Avoca. Seventy thousand acres have been bought from the State, and the St. Paul and Sioux City Railway Company, the first pioneers, arrived twelve months ago. Now there are thirty families, some still in tents; but a chapel, school, and store are built. Neither here nor in any other of Bishop Ireland's townships are any intoxicants allowed. Railroad, park, and grand avenues are staked out; thirty town lots, 22 feet by 150 feet, are sold for shops; some residential lots of 66 feet by 165 feet have been also disposed of. The plans and site for a good hotel are fixed on, the Bishop with liberal spirit determining that his hotel keeper shall be a Protestant.

A park is reserved running down several hundred yards to the margin of the lake, about two miles long, around which it extends, and water is abundantly supplied from the lake and from wells 20 feet to 30 feet deep. Father Koebrel, who concentrates in his own person the functions of priest, mayor, architect, and surveyor of the new colony, expects by this time next year to have a hundred families comfortably housed. Some of the people are recently from Ireland, but most are from Canada. Several houses are finished and occupied; a dozen are in course of construction, most of them of two stories, measuring 24 feet by 16 feet, with three rooms above and the same number below. Inch boards ready dressed cost $16 per 1,000; doors and windows frames come ready to be put in; wooden shingles are used for roofing. The contract price for the artificers' and laborers' work is $33; the total average for the completing house is $250.

The Black Hills Railway, begun last spring, now extends forty-five miles from Heron Junction, and is destined to be pushed along northwest four hundred miles through the prairies, so recent the hunting grounds of the Dakota Indians, over the Dakota river towards the Missouri, to tap the mineral riches of the Black Hills. Ten miles north of the railway runs the old Dakota track, along which are numerous settlements, and where wheat has been grown for twenty years consecutively on the same good soil.

Back we run to Heron Junction, where, although 900 feet above St. Paul, the land appears rather wet, but the sedgy lakes afford good lodging for wild fowl, and eighteen miles down the main line we reach Worthington, a place of seven hundred inhabitants, colonized from Oberlin College, Ohio, and determinedly upholding the Maine Liquor Law. Close by the railway is a flour mill, where the fuel used is hay and rushes, part of it cut during winter by running the mowing machine over the frozen prairie and lake banks. This readily collected fuel costs $1½ per ton, and the usual daily consumption is seven tons. At Worthington I attended a county agricultural exhibition, which, although the first attempted, attracted a goodly show of stock, implements, and general farm produce. The live stock was not in the high condition usually seen at English county exhibitions; the horses showed most need of improvement; but there were some useful shorthorns and grades; a good red ten months' shorthorn bull scaled 900 lb. Some of the grades were scarcely distinguishable from the pure breeds. The sheep were chiefly the produce of Glocestershire-Cotswolds from the Norwegian like ewes of the district, which are worth $2½ to $3 each, and there are few pens of merinos and merino grades, which, although paying well with their fleece, are not profitable as mutton producers. Capital potatoes and tomatoes are exhibited, and several specimens of amber sugar cane, with its sirup and crystallized sugar, which is easily cultivated, and reported to pay $30 an acre.

One of the best farms I have seen in Minnesota is Messrs. Thompson and Warren's in Rock county, two miles from Luverne town and station, and comprising 38,000 acres. The first sod was turned in May, 1877, and fully 1,500 acres have each year been brought into cultivation. A good house has been built, with barns, two lots of barracks capable of accommodating 70 men, stabling for 200 horses or mules, with some shedding and pigsties. To break the wind, attract moisture, and beautify the estate, trees, mostly of cottonwood, are planted about half a chain apart around the roads which surround the sections. White willow hedges, which make capital fences, are also planted, and it is intended to follow the successful example of some of the neighboring small holders and plant fruit trees. On the prairie sod turned in during May and June, Indian corn is sometimes immediately dibbled, and the hastily prepared crop usually yields 15 to 20 bushels an acre. On other portions of the newly-upturned prairie navy beans are drilled or dibbled about June 1, are pulled about the middle of September, and although only yielding three to five bushels make about 5s. per bushel and, like the corn, constitute a good preparation for the subsequent wheat.

These and other stubbles were being plowed up. In one field were at work 25 "Casiday's sulky plows," made at South Bend, Indiana, costing $65, and each drawn by four horses or mules. Three draught animals are often used; but two months' continued dry weather having hardened the soil, the plowing is fair work for four. The working parts of the plow are of cast steel; a metal disk suffices instead of the colter in the soft fen-like soil; the axle is bent, so that the wheel in the furrow goes at an angle of about 60°. Small skims turn in the stubble and any weeds, of which, however, there are few. Three acres are turned over daily by each team, which does, morning and afternoon, its five bouts of a mile out and in. Accompanying the plow is a foreman on horseback, hired for the seven or eight months at $50 a month. The plowmen are engaged from the 1st of April to the 15th of November, or until the end of the season, at $18 a month, with board. The dietary, which differs little at the three meals, consists chiefly of bread and butter, fresh and salt pork, fried or boiled; beef once or twice a week; baked or boiled potatoes, and other vegetables, pickles, and fruit, with coffee and milk. A cook and his mate are attached to each of the two barracks. No beer or spirits are allowed on the place. Half the wages are paid every month, the remainder at the close of the season. For harvest, thrashing, and other work extra men are engaged at a dollar and a quarter per day, with rations, which are valued at 25c. The men are rung up at 4:30 A.M.; feed their mules; clean out stables; breakfast at 5:30; feed, harness, and start their own teams at 6; do about ten miles on the sulkies; stop at noon and, unless near home, have troughs and nosebags for the mules at a field barn, where their own dinner is also forwarded. Out again at 1:30 P.M., they continue until 6 or, when drilling, harvesting, or at other important work, until dark. On Sundays the men are not expected to turn out until 7. Excepting in harvest, no work is done on the day of rest unless it is the washing of clothes. Some of the men go to church.

Mules, although costing quite as much money, are preferred to horses; they stand the heat and annoyance of flies better; long days do not generally knock them up; they are always ready for their food, which consists of a mixture of two-thirds oats and one-third Indian corn, and of this they have 16 lb. to 18 lb. daily, or nearly as much as they can eat. They do not use more than 10 lb. or 15 lb. of hay. Fly nets are employed in hot weather. The flies being so troublesome in June and the first fortnight in July, the mules paw and strike with their feet, and the ground being dry and hard they are sometimes shod in front. At other times shoeing is unnecessary. The mules stand 16 hands high, weigh 1,200 lb. to 1,300 lb., and cost about $120 in Missouri, whence it takes about $10 to bring them home. Several ox teams are kept. They cost per pair, when ready broken at three years old, $120 to $125, and last four years. A man and his pair of mules can be hired at $1½ to $2 per day, the hirer feeding the man and his beasts. Autumn or fall wheat is not used—the severe winter is apt to throw it out; but Mr. Warren purposes trying it, as is done in Illinois, along with one-third of a seeding of oats, which grow up vigorously and protect the wheat, although they perish in the service. Hard Minnesota wheat is put in with the broadcaster early in April, and is generally up in a week. The harvest begins about July 12; 25 cord self-binding harvesters are at work, and three machinists are engaged to superintend the harvesters. The grain is cut and carried within 20 days. This year's yield varies from 7 to 15 bushels. One field, owing to the spring drought, proved so indifferent that it has never been harvested.

Indian corn is sometimes planted, as already stated, on the spring-plowed prairie sod, but greatly better crops are produced when the land has lain plowed throughout the winter, and the sod has thus been thoroughly rotted, or when the corn follows a crop of wheat. Dibbling is then done late in April or in May, usually with a machine which deposits two rows of seed at intervals of about three feet in rows, four feet apart. The surface is repeatedly harrowed, and, as with beans at home, may be again harrowed while the corn is coming up. As the crop is growing it is cultivated several times between and across the rows, a lad and a pair of mules doing two rows together and overtaking twelve acres daily. Corn enjoys the singular advantage of remaining uninjured, no matter how long harvesting is postponed. A great deal is still standing ungathered. When the straw as well as the grain is to be used, it is cut, bound, and shocked, and often rather untidily left standing in the fields until it is required for the cattle in winter. Frequently the cobs are gathered from the standing corn at a cost of $1 for fifty or sixty bushels, and the corn stems dragged out by an old iron rail 28 feet long, mounted on 6-inch wheels, and drawn by a couple of mules over the field. The corn stems thus pulled up are raked together and burnt, and if the cultivation has been effectual the land requires no plowing for wheat. On this Warren farm the yield of corn, free from the cob, is fifty and occasionally sixty bushels per acre. The cost of production is about two-thirds that of wheat.

A magnificent crop of clover and Timothy grass is found in one of the wheat stubbles. A hundred acres of seeds sown with the grain in April were (11th of October) strong enough for mowing, and were intended next spring to be grazed with pigs and horses, perhaps with sheep, of which Mr. Warren purposed purchasing 2,000, and feeding them throughout the winter, chiefly in yards, on corn, bran, linseed, and barley straw, which is here preferred to oat straw as fodder for stock. No cattle as yet are kept. The heaps of good manure from the stables are only used occasionally in the garden, where the vegetables in luxuriant variety amply attest the productiveness of the soil. So little value is attached to the manure that Mr. Thompson remarks, "I would gladly give $100 to have 1,000 tons cleared out of the yards; for," he adds, "it does not at present pay to use it, and for years the deep good soil will require no help except from clean thorough cultivation." Good cultivation has certainly demonstrated the capabilities of this soil, which, if in England, would grow four to five quarters of wheat, or would be anxiously looked after for market gardening. For portions of the estate which four years ago cost $6, $12 to $15 have lately been offered.

Five miles from the Warren farm are the wonderful "Luverne Picture Stones." From the bosom of the level plain a great hill, ten miles in circumference, appears to have been upheaved; the red ferruginous quartz rock, sand and wind worn, is thrown into quaint, weird shapes, larger and more numerous and varied than the remains on Salisbury Plain. Along the eastern rampart pillars, not unlike those of Samson's Ribs, south of Edinburgh, rise abruptly 100 feet. In sheltered nooks are beautiful mosses, ferns, and cacti. From the elevated plateau a magnificent view, extending thirty miles in every direction, is obtained of the rolling brown prairie, diversified by the silver sheen of lake and stream, and the extending cultivated fields of yellow wheat and corn.

FRUIT CROP OF THE COUNTRY.

THE Committee on Statistics, in making their report to the above named society, placed the annual value of the apple crop of the United States at $51,000,000, of which Ohio supplies over $7,000,000. The whole peach crop is estimated at $50,000,000 and the pear crop at $15,000,000. The strawberry crop is placed at $5,000,000. Exported canned fruit is estimated at over $1,000,000 annually.

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